Materials Engineering in Product Design + Manufacture

Materials & Methods

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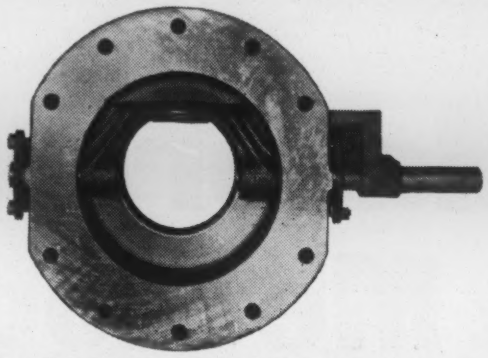
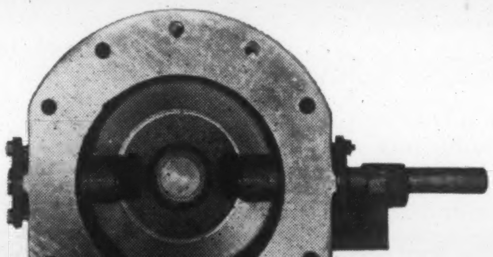
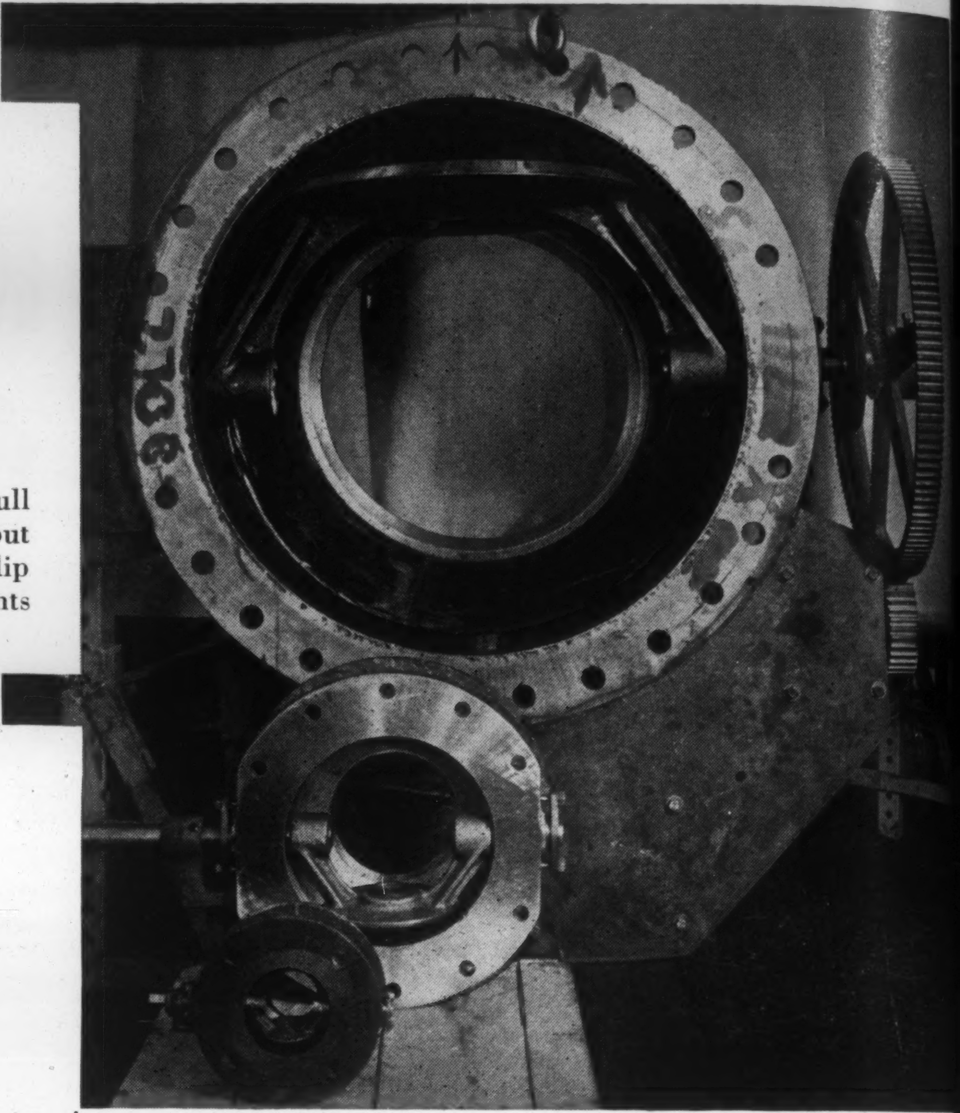
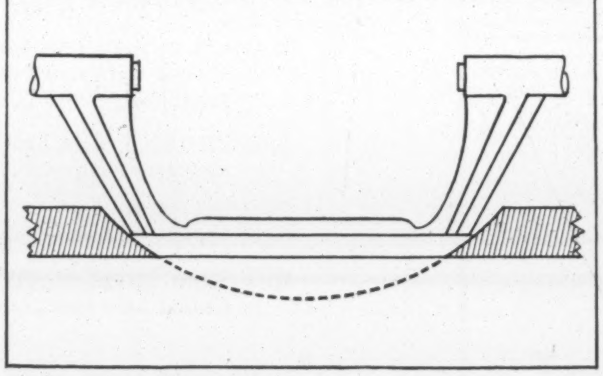


Open Position. Notice how disc swings full open in ¼ turn. Material flow is aided but danger of abrasion and erosion of seat lip is increased. Inco Cast "S" Monel prevents harm from these sources.



Closed Position. As disc wipes across seat it removes clinging powders or pastes, then seats watertight. Inco-Cast Monel and "S" Monel construction withstands tumbling shocks, corrosion, constant abrasion, and galling.





For Rugged Duty such as handling fluorine- and hydrogen-treated solids and slurries, (up to 700° F.) General Machine Company of New Jersey relies on Inco-Cast Monel and "S" Monel to give extra service life to their self-cleaning dry valves. Drawing at left shows self-cleaning principle.

Seats perfectly after 5 years

...and 1,250,000 openings and closings

Every 3rd minute, 24 hours per day, 5 days per week for over 5 years . . . 1,250,000 times in all . . . a dry valve similar to those shown above has opened and closed. In all that time it has given no trouble, still seats perfectly.

What's it handling? A gritty, abrasive limestone-like powder that liberates highly corrosive fluorine.

How does it operate? The disc arcs across the seat with a self-cleaning wipe. Clearance is tight, galling and abrasion could be severe.

How's it made? Body and disc are Inco Cast Monel®. Seat is Inco Cast "S"® Monel.

When you get this team of Inco Cast alloys on your side, valves can be expected to give long service. Both alloys resist abrasion and corrosion and, when worked against each other, they show remarkable immunity to galling. Both are cast to last. Age-hardenable "S" Monel provides extra "slippery" hardness.

Chances are you know Monel well... but you may not be so familiar with "S" Monel and what it can do to lengthen equipment life. If not, write today for a free copy of "Engineering Properties of 'S' Monel." For information on the dry valves illustrated, write General Machine Company of New Jersey, 401 Market St., Newark 5, N. J.

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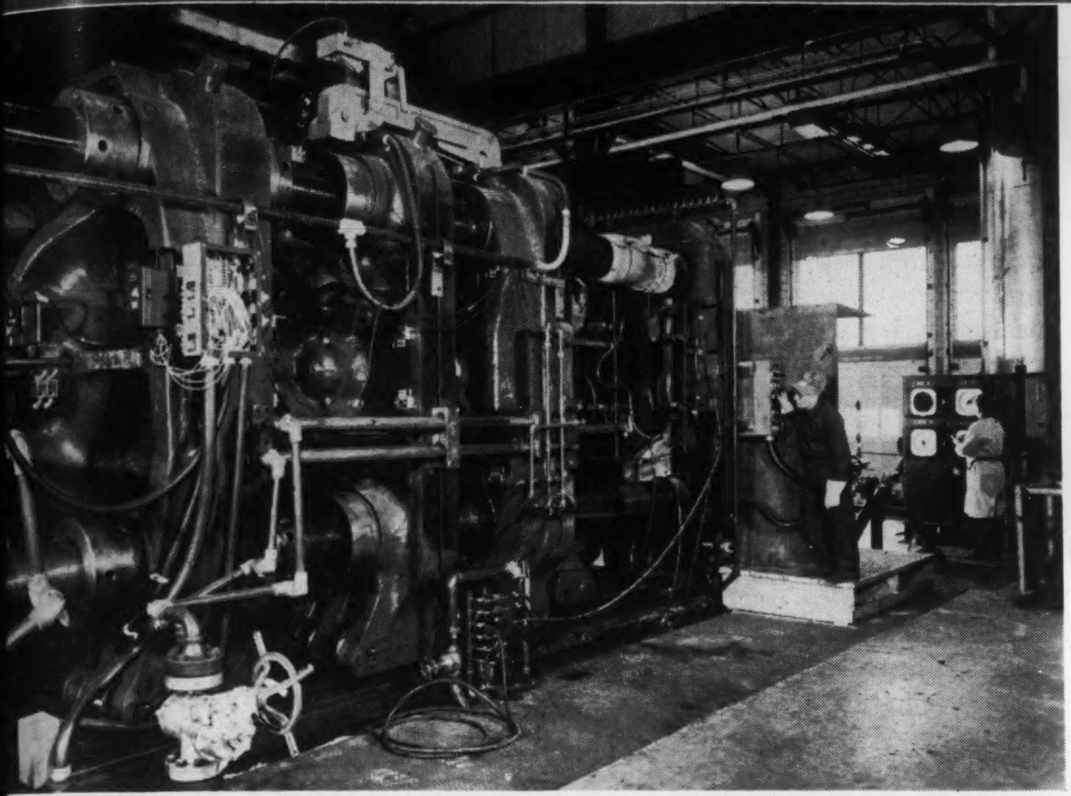
MATERIALS ENGINEERING **News Digest**



World's largest die casting machine can turn out aluminum parts.

New Machine Can Die Cast Aluminum Engine Blocks

A Toledo, Ohio die casting concern has set out to prove to the automotive industry that larger aluminum die castings are in the cards for tomorrow's cars and trucks. By December, the Doehler-Jarvis Division of National Lead Company plans to have die cast aluminum engine blocks to show to automobile manufacturers. The blocks will be cast on a new 72-in. die casting machine which was unveiled last month as a joint project of Doehler-Jarvis and Kaiser Aluminum and Chemical Corp.

Company executives frankly admit that the machine was conceived and built to show automobile manufacturers how die castings can meet large part requirements at lower cost. The big new 72-in. machine may be able to do it. It is capable of turning out 75-lb aluminum die castings at a rate of one every two minutes, compared to previous maximum practical weights of 20 lb. Adapted to zinc, castings up to 200 lb may be possible but right now the primary target is aluminum.

Increased use of large aluminum die castings for such applications as torque converter housings for automatic transmissions and for heavy grill parts is interpreted as a trend by some engineers inside the automotive industry and among the ranks of its suppliers. The unveiling of the big die caster will undoubtedly quicken thinking along these lines.

Frank J. Koegler, General Manager of Doehler-Jarvis said, "We have learned while developing the large die castings now in common use in the automotive industry that we can make aluminum die castings to compete with those usually made in cast iron." He believes that larger die castings will fill a definite need because, "Weight has been an ever increasing problem in the automotive industry. We are convinced that aluminum is the answer to this problem—especially with the newer developments being added to cars, such as power brakes, power steering, and the almost universal use of automatic transmissions. Add to these possibilities the use of aluminum die cast motor blocks, instrument panels, rear deck lids, door frames and other large pieces." D. A. Rhoades of Kaiser Aluminum emphasized the point that "The fact that large die castings are now commercially available for the first time will inevitably lead to their design and use in a variety of new applications." He reported that market studies conducted by Kaiser Aluminum indicated a ready market for larger aluminum die castings than are now available.

The increased use of aluminum in automobiles cannot be disputed, but the resistance to the use of light metal where steel or iron is well established is formidable. The first question with automobile men remains cost, not weight, and like men from Missouri, they have to be shown before they will buy. Unless a new feature will provide a sales gimmick or a price cut it won't get much consideration. The Detroit fraternity believes, and is probably right, that John Q. Public doesn't care what the block of his Super 8 is made of as long as the motor starts when he steps on the starter on a cold morning. On top of that, most Americans like big, heavy cars.

Automotive engineers are not wholly unconcerned with weight, since what they term "performance" in an automobile is basically its power weight ratio. However, they have a solution for increased performance which is far less expensive than major component changes which require retooling. A few minor changes in any of the present new engines will boost their horsepower and change the power weight ratio significantly. In addition, they can claim that the customer is getting more for his money. So as long as the American driver is willing to haul a few tons of steel around with him, everybody is happy with the status quo.

Aluminum's major new uses in the automobile industry will probably be limited to accessory type equipment and perhaps some major components of high performance sports-type cars if that field continues to grow. To convince automobile production men that aluminum cylinder blocks are practical, the die casters will have to come up with some astounding cost figures. Even so, the investment in foundries and tools for iron and steel insures that the old standbys will be slow to die.

NBS Chief Calls for Plastics Institute

A call for the formation of an industry-supported plastics institute has been made by Gordon M. Kline of the National Bureau of Standards.

Dr. Kline, who is chief of the NBS Division of Organic and Fibrous Material, spoke at the annual conference of Society of the Plastics Industry held at Cleveland in June. A dynamic program of research and engineering studies on plastics calls for industry cooperation and teamwork, he said. The record of similar activities in other industries indicates that now is the appropriate time to plan and organize such an effort through a plastics institute.

According to Dr. Kline, a significant part of the research program must be directed toward advancing our knowledge of the fundamental relationships between the structure of polymers and their properties. As examples of fundamental research having important potential applications, he cited five programs now under his direction:

Crystallization

● The physical properties of organic polymers and their ultimate end uses as rubbers, plastics or fibers depend to a marked extent on the presence or absence of crystallinity and the location of the melting temperature. Recent work has shown that crystals in polymers are formed from nuclei that are produced at an approximately constant rate, and the crystals grow at a constant rate after initiation. These observations permit the application of much of the theory of crystallization in metals to the study of polymers. These results can be used to predict conditions respectively favorable or unfavorable for crystallization to occur.

Bulk Modulus

● Considerably less is known about the bulk modulus of polymers than about its shear modulus, both from the point of systematic experimental results and molecular interpretations. Some static data are available, although no consistent picture relating such phenomena to structure seems evident at the moment. These measurements should have a considerable bearing on our understanding of the change in properties at the transition from rubberlike to glassy behavior, and should be continued in conjunction with other experiments designed to elucidate the nature of this change. A method of measuring dynamic bulk modulus directly is being sought.

High Strain Rate

● An instrument has been built for investigating the behavior of natural and synthetic fibrous materials under high velocity impacts. The results obtained to date are leading to new concepts of fiber properties. Basic mathematical formulas are being derived for the velocity of strain propagation and for the strain, stresses, strain energy and kinetic energy developed at these high rates of straining.

Craze Prevention

● Basic research on the nature of crazing has led to a method of orienting polymethyl methacrylate by multiaxial stretching of the heated cast sheet approximately 100%. The resulting toughened sheet gives promise of being sufficiently shatter-resistant to serve in place of the conventional laminate made with a polyvinyl butyral interlayer as a glazing material on pressurized aircraft, thus effecting savings in cost and weight. The stretched material is also free from the tendency to craze and crack under stress, a troublesome and costly fault of the ordinary cast acrylic plastic.

Irradiation

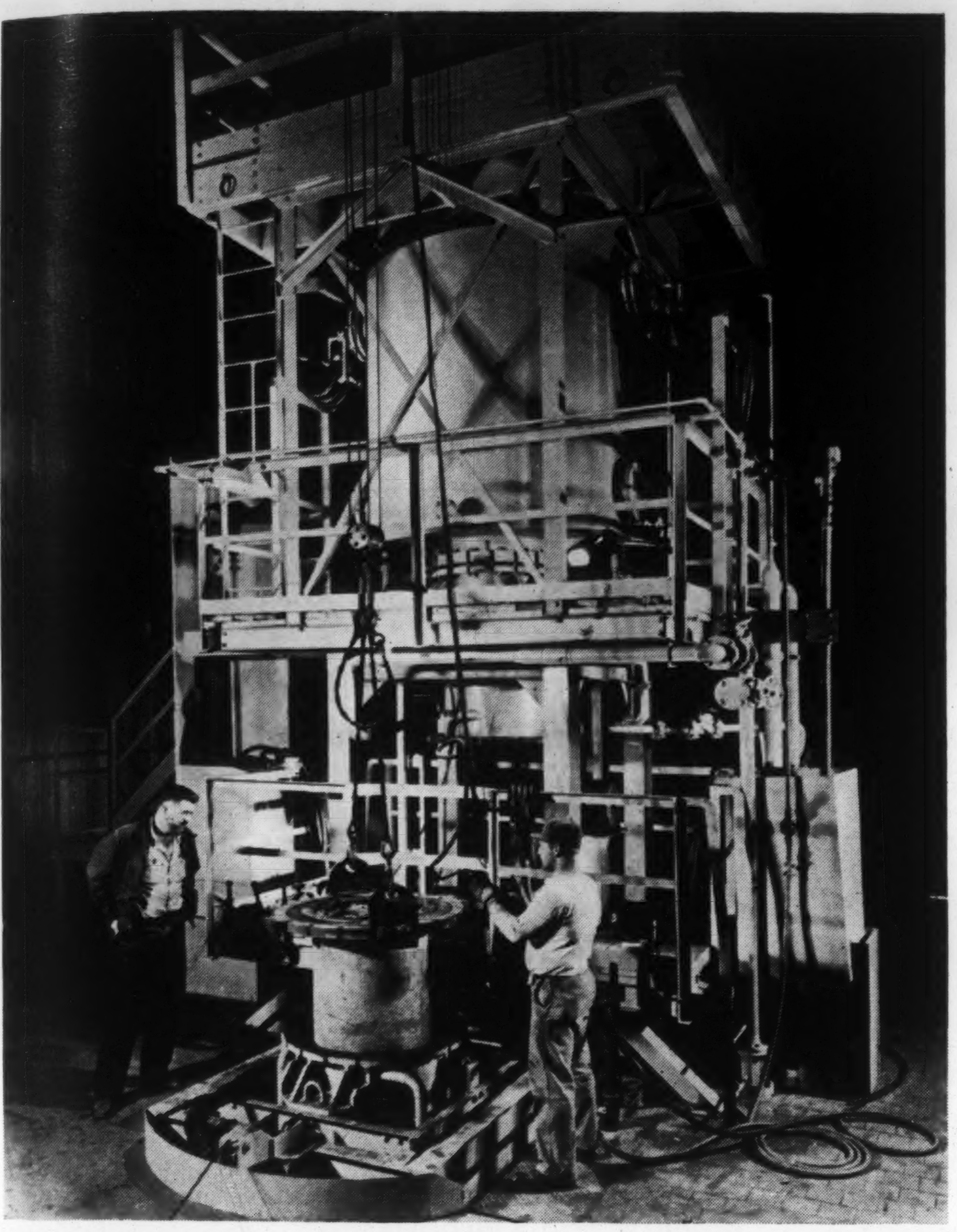
● Whereas cross-linking by chemical additives usually leads to network formation and therefore reduced formability and increased brittleness, cross-linking by nuclear or gamma irradiation offers the possibility of limiting the cross-linking to the tying together of two or more large molecules linearly. This should lead to a product with higher softening point and greater toughness, but one which is still capable of being formed.

The conference also heard a review of present information on irradiation of plastics by David S. Ballantine of Brookhaven National Laboratory. Polyethylene continues to attract most attention. Not only can it be cross-linked by means of irradiation, but work by R. D. Bretton at Yale University and by J. J. Martin and his associates at the University of Michigan indicates that polyethylene may be synthesized at relatively low temperatures and pressures. Extreme operating conditions and close control are presently needed for the commercial production of polyethylene. According to Ballantine, Bretton is working at room temperature and atmospheric pressure and studying the problem mainly from a theoretical viewpoint. The Michigan group, working at room temperature and about 1000 psi pressure, have been able to produce 100-g amounts of the polymer and are currently studying its physical properties.

Controversy on materials for tooling dominated a session devoted to automotive applications. The cases for cast phenolics, glass-reinforced polyesters and epoxies were presented respectively by Robert H. Voss, of Warren Plastics & Engineering, Inc., Fred Lyijynen, of Chrysler's Automotive Body Div., and George M. Rice, of Ren-ite Plastics, Inc. Materials with improved heat resistance are being sought, and interest was expressed in the possibility of glass-reinforced phenolic laminates as a possible solution to this problem.

Other conference sessions were devoted to present and potential applications of plastics in radios, television sets, refrigerators and air conditioners, and to the impact of new vinyl forms and rubber-resin blends on conventional rubber applications. It was stated that polyvinyl chloride, modified with 5-15% rubber, has an Izod impact value of 15-17 ft-lb/in. which compares favorably with that of styrene-rubber blends.

The exposition accompanying the conference offered few surprises to those who had kept reasonably well abreast of technical developments in the past two years. Of particular interest was the process demonstrated by B. F. Goodrich Chemical Co. in which rigid polyvinyl chloride sheet (Geon) is fed from a reel through an oven and formed in a 10-sec cycle on a conventional metal stamping press. Both new materials and new automatic machines testified to increasing interest in vacuum forming. Altogether, 172 exhibitors were represented at the show, and attendance totaled almost 18,000. Conference sessions drew 1058.



4000-lb titanium ingot is lifted from well of a 20-ton automatic double melting vacuum furnace. Recently installed in the Henderson Nevada plant of Titanium Metals Corporation, the furnace works on a vacuum principle rather than with slightly positive pressures of argon and helium. Low hydrogen content titanium with improved homogeneity is produced, the company claims.

Tinplate Substitutes Studied by Can Company

Untinned steel, specially treated steel, aluminum, and zinc-, aluminum- or nickel-coated steel are among the leading materials under consideration as alternates for tin plate for metal can production. Adhesive bonding holds promise for many can applications.

Three research engineers from the American Can Company reviewed the status of alternate materials for metal cans in a paper delivered to the Institute of Food Technologists. Dr. R. H. Lueck of American Can pointed out that over half of the world's tin production lies in the immediate path of calculated communist agression in Indochina and that the long sealanes would be hard to defend in case of war emergency. He said that the government's stockpiling program provides short term insurance against shortages, but a long term program must result in the development of tin-free cans—first for industrial and household non-food products, and ultimately as food containers. The present Canco program differs from previous "conservation" programs in that it is not limited to materials and methods tied to existing production facilities. All possible alternates and manufacturing techniques are being reviewed and evaluated.

In reviewing the characteristics of tin plate, Dr. Lueck said "Tin plate is so unique that many believe the canning industry grew as it did around the properties of the tin steel combination." Even with tin plate, however, can manufacturers tailor make the cans for each application, considering the reactivity of the product and the stresses that the can will encounter during processing and distribution. As far as strength is concerned, the manufacturer has a choice of six tempers, ranging from T1, the softest tinplate practical for mill production, to T6, the stiffest plate practical for handling on can manufacturing equipment.

New Materials

Steel, because it is the only sheet material produced in anywhere near sufficient quantity to meet the demand for 35.6 billion cans annually, is and will probably always be the leading material for cans. Untinned steel is a leading candidate for tin free cans, not only because of its availability, but because its mechanical properties are essentially the same as those of tin plate. Untinned steel, however, must be enamelled on both sides to prevent corrosion, while electrolytic tin plate can be used as is for many applications.

Side seam closure of tinless cans poses a new problem, since it is not possible to solder steel plate. Several methods of welding black steel plate and other sheet metals have been investigated, but the welding problems have been different from any others encountered heretofore. Research is continuing on welding and the can company engineers held that it is quite possible that the process will become more important in can manufacture in the future.

Adhesive bonding is finding wide application in tinless containers. At present most oil cans are made of CMQ black plate with cemented side seams and the cementing procedure is rapidly expanding to include containers for other styles and sizes of cans. The absence of a solder seam in adhesive bonded cans offers the additional bonus of all-around lithography.

Canco engineers believe that chemically treated steel plate will be one

(Continued on page 191)

Marvibond

New vinyl-to-metal laminating process

Naugatuck's new and exclusive laminating process bonds Marvinol® vinyl sheeting to practically any kind of sheet metal—permanently! It gives metals all the famed corrosion and chemical resistance of vinyl plastic, one of the most inert of all known materials!

New Marvibond laminates end rusting—resist acids, alkalies, salt water, alcohol, household chemicals, corrosive industrial liquids and atmospheres . . .

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- **withstand weather and humidity indefinitely!**
- **remain dimensionally stable up to 250°F!**
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- **will not chip, crack, craze, or flake off!**
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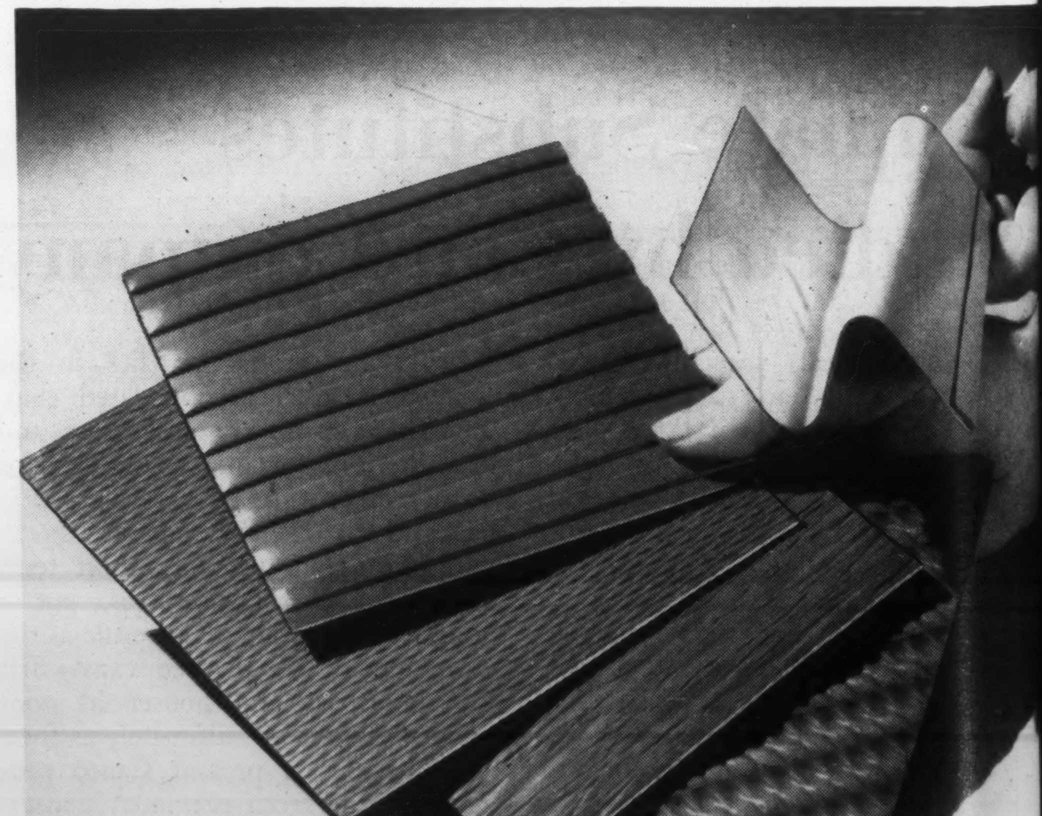
- **can be deep drawn, sheared, crimped, bent, embossed, drilled, and punched—with standard tools—*without damage to coating or bond!***
- **and cost less than stainless steel!**

Since Marvibond involves lamination rather than spraying, it gives all the excellent chemical, abrasion, and heat resistance of a polyvinyl chloride—protection not obtainable with a solution grade vinyl. *And it gives this superior protection at less cost.*

Illustrated are just a few of the many forms and products into which Marvibond has been fashioned—suggesting the tremendous scope of product possibilities this new process opens up.



Materials & Methods | August, 1954

—One Point of View

A Big Help—Perhaps

Did you ever wonder what, if anything, all the alloy numbers meant when you dealt with wrought aluminum alloys? Usually they meant very little, possibly nothing more than an experimental number or the whim of some sales executive. Things are soon to be different though.

Effective October 1, 1954, a new system of alloy designations will be applied to all wrought aluminums and aluminum alloys. Based on other 4-digit systems, numbers have been assigned to tell certain things about the alloy. The first numeral will tell which element is the major alloying constituent, the second digit tells whether there are modifications in the alloy's composition, the final two digits are purely for identification. In many cases, old alloy numbers are retained in the final two digits. For example, the familiar 75S now becomes 7075.

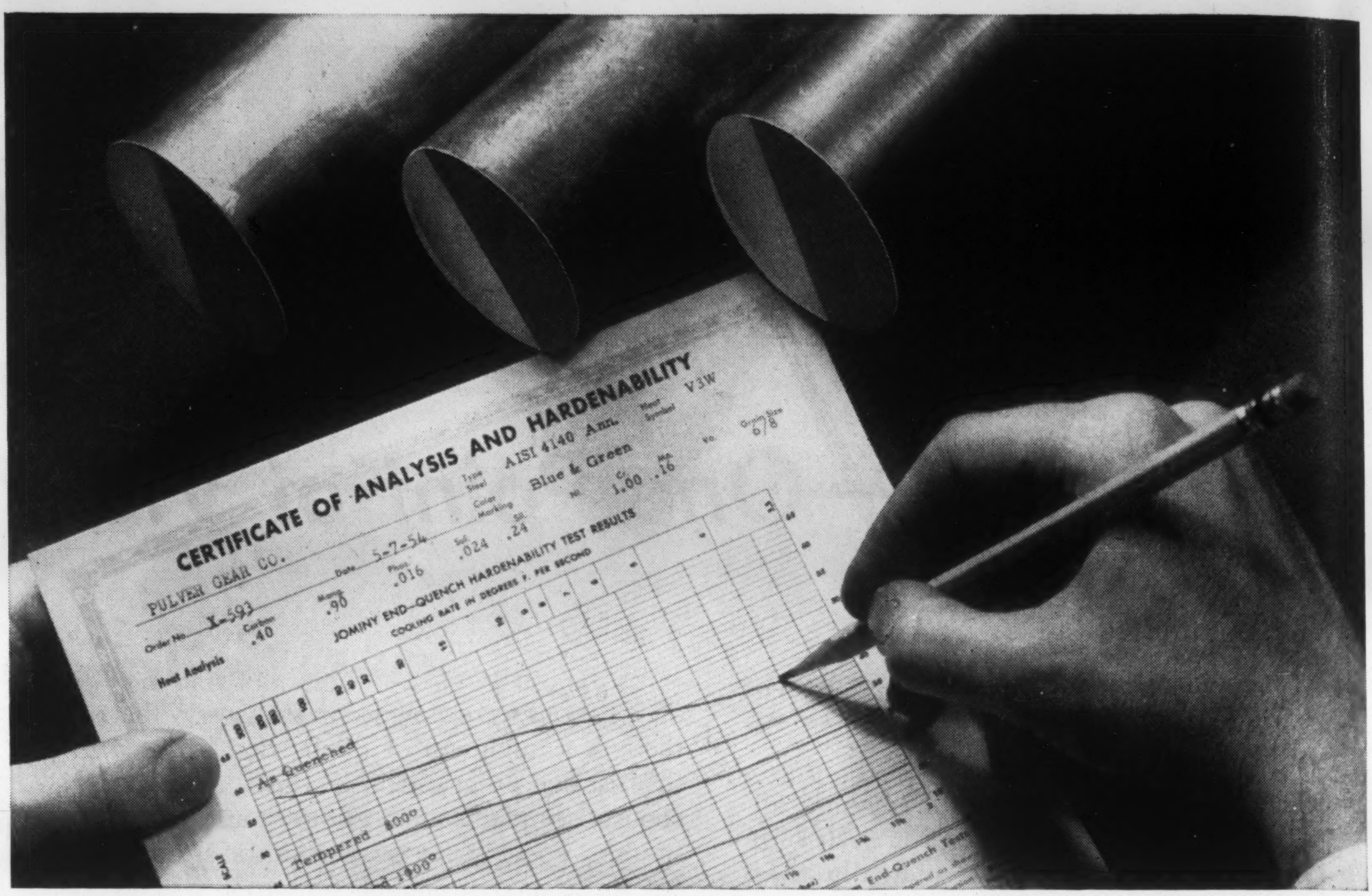
Generally speaking, we like the new system, but can foresee a possible difficulty which might result from the impending change. Although it seems obvious that the designations were assigned in such a way that there is a minimum of duplication between this list and other established lists, there are enough similar numbers to cause some trouble. Possibly this is a pessimistic attitude, but we have seen enough foolproof systems go awry to convince us that the general public can really foul things up without any effort whatsoever.

Possibly the addition of the temper number when referring to the wrought aluminum alloys will keep some people from confusing them with steels, but the probability is great.

What's the answer? It would seem that each individual specifying an engineering material should use the letter designation of the identifying group as well as the numerical designation. Chances for error are greatly reduced if the alloy is designated as AA 1030. That identification cannot be mistaken for SAE 1030 or AISI 1030 or JAN 1030 or any other 1030.

Despite our slight reservation, we are anxious to applaud the efforts of the aluminum industry to create some order out of what has been chaos. If only something like this could be done in the plastics industry.

T. C. Du Mond



CERTIFICATE OF ANALYSIS AND HARDENABILITY
PULVER GEAR CO.
Order No. X-593
Date 5-7-54
Type Steel AISI 4140 Ann.
Heat Symbol V3W
Color Marking Blue & Green
Heat Analysis
Carbon .40
Mang. .90
Phos. .016
Sul. .024
Sil. .24
Cr 1.00
Mo. .16
Grain Size 6/8
JOMINY END-QUENCH HARDENABILITY TEST RESULTS
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As Quenched
Tempered 800°
1000°
End-Quench Test

Steel user drops own tests

relies on pre-tested Ryerson alloys

A manufacturer reports that it was standard practice with his company to run a pilot hardenability test on all alloys, regardless of source. But after checking their results over a period of time against Ryerson Certificates of Analysis and Hardenability, they decided that our alloy steel and our Certificates were so completely reliable that the pilot run could be discontinued. The result: a definite saving in time and money.

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You don't have to run analysis or heat treatment response tests on Ryerson Certified Alloys. You save time and money because these tests are run and recorded for you as a part of the exclusive Ryerson 8-step quality control plan.

Starting with the careful selection and identification of every heat carried in Ryerson stock, this plan assures you of quality steel—steel of known analysis and known performance. It means that tested alloys, racked separately by heats, are accurately prepared to your specification and shipped to you with test data to confirm quality and guide heat treatment.

Yes, you save time and money with Ryerson Certified Alloys . . . yet you pay no more. To get these dependable controlled-quality steels promply, call your nearby Ryerson plant.

RYERSON STEEL *Principal products in stock: bars, structurals, plates, sheets, tubing, alloy and stainless steel, reinforcing steel, etc., also machinery and tools.*

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Ten Laws of a Materials Department

Here are ten laws that appraise informally, but realistically, the environment within which a materials group must work. An understanding of these working conditions should further smooth and efficient operation.

by MERRITT A. WILLIAMSON
Manager, Research Div., Burroughs Corp.

● THE GROWTH IN the number of useful engineering materials, the increasing severity of operating conditions for many manufactured products, and the hard facts of competition have combined in recent years to multiply the problems associated with the proper use of engineering materials. The result in many manufacturing companies has been the formation of a Materials Department to deal with these problems.

You who are associated with a Materials Department know that many important decisions had to be made before you could get started. The company had to determine the extent of the job to be performed by the new department, the proper position of the department within the over-all organization, and how to set up the department with the least disruption to all concerned. All of these decisions continue to affect your job, but you can no longer be concerned with them. What you want to know is how to operate a Materials Department, day by day, with maximum efficiency and minimum friction.

As the accompanying list of possible functions clearly indicates, the Materials Department is a service group. If you are to operate smoothly and efficiently, therefore, you need to understand the environment within which the Materials Department must work. The ten laws presented here are an attempt to formulate informally the proper relationship of the Materials Department to its environment.

MATERIALS-DEPT.

Law 1 Management will never show the appreciation of the importance of the Materials Department which those working in it feels it deserves.

Consequently, keeping in mind the limitations of Law 7 (see p. 79), how do you get as much appreciation as possible? What *does* management appreciate? Better products at lower costs is the simple answer, and management will be impressed if it is made to realize that the revenue-producing departments seek out the assistance of the Materials Department. It will not be impressed by a simple statement such as "we gave advice in response to 65 requests last week," but numbers, properly backed up, can be impressive. Everyone who confers with you, by this very fact, acknowledges your assistance. If suitable records are kept, each request helps paint a picture of your value to the company. A suggested form to be filled out by the Materials Department for each request is shown on this page. Management can then be told in statistical reports who seeks your services, how many opinions are given, how many tests are carried out and how many reports are written. A record of the subject matter indicates the quality, as well as the quantity, of your effort.

That is not the whole story, since your job is not confined to answering requests. Suppose you run tests on a new material and send the samples, reports and manufacturer's data to the design department. A designer may be able to use that material with

Sample Request Blank

Date:
Time:
Requestor: **How received (phone, memo, conversation, etc)?**
Requestor's dept. and phone no.:
The question (briefly):
Project number or reference to broad problem:
Time when answer is needed—priority:
Answer given (briefly)—data supplied and references—commitments for future:

resulting production economies. You will gain nothing by publicly claiming credit for the idea. However, after the benefits of the change have been acknowledged, you might see that the dates on which this information was first obtained and given to the designer are passed on to management confidentially in a monthly report. The only danger is that someone topside may want to give you public credit. Even though your management may be tempted at times to remind managers of other groups that their personnel are not quite as creative, imaginative and resourceful as pictured, you must make certain, in the best interests of the Materials Department, that management remembers Law 7.

POLYCHLOROTRIFLUOROETHYLENE

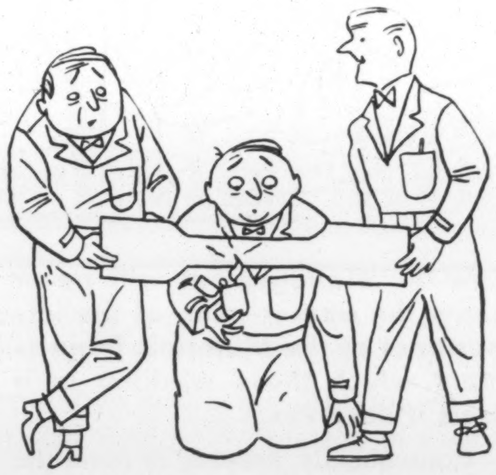
Law 2 The Materials Department will never be staffed with personnel competent in all fields in which it will be called upon to advise.

Accept this limitation and do not be unhappy. If requests continue to come in on a subject you cannot handle within the organization, your records will enable you to produce numerical proof that you need a man in this area, and they will also show you which operating departments will back up your request for additional staff.

If the requests are occasional you must find another way of meeting the requirement. Sometimes you have to develop experience on the part of someone who is close to this field and is already part of the team. The best way to do this is to send him to a producer's plant or laboratory so that he can see their test procedures, talk with their technical men and return with as much literature as possible. Another way is to have him visit the materials department of some other company that buys this particular material. Perhaps a visit to a competitor might not be in order, but there are usually other industries interested in a particular material that are non-competitive. An industry association research laboratory often may be helpful. Independent consultants and college professors are other possible sources of help. The personal contacts of your staff are important. Whenever you seek outside help, however, you must be prepared to give some help in return. Cooperation is not a one-way street.

Law 3 The Materials Department will seldom be asked questions it can answer immediately and unequivocally.

This is annoying, but logical. You are putting information in the hands of designers and engineers who use it regularly and, every time you do so, you are educating them. If you get the same request for the same reason from the same engineer over and over again, either your teaching is not effective, or someone will catch up with your questioner sooner or later and he will not be asking you questions any more. It is a compliment and a healthy situation if you do not get routine requests. Consider your time too valuable for these and pursue the unknowns.



Law 4 The Materials Department will never have all the capital equipment it needs to find answers.

Accept this as you did Law 2. Above all, do not use every request for assistance as an excuse to acquire more equipment and more space. Keep an eye on the economics of the situation. Properly kept records will give you the data you need to substantiate a request for additional equipment that is really needed. Savings in money spent or in time lost in delays are your best selling points. Where the request is occasional and time not too critical, however, an outside testing laboratory may be the answer. It may be a commercial laboratory, another industrial laboratory for which you can do occasional favors, or perhaps the laboratory of an educational institution. A little ingenuity will find you a source for occasional testing.

Law 5 The Materials Department will always be asked for an answer within a time limit that is too short.

However, it is bad psychology to even hint at this law to an engineer or designer seeking help on his first contact with you. Nothing is more irritating to him than to be told that a project requiring several months must be set up when all he wants is a simple answer to his request. He is justifiably impatient with any attempt to "research the hell out of it." Merely tell him you have to look into it further and set a time when you will call him back and tell him what is involved. When you do call back, break it to him gently, but honestly. Be sympathetic with his time schedule and tell him what corners you can cut, but let him know the resulting effect on reliability. Actually, you may as well set up the work immediately, since the chances are eight to one the allowable time will be increased. A fast start will improve your chance to be of some help.

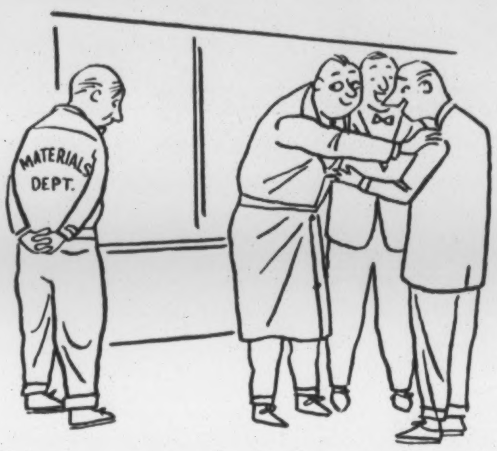
MATERIALS DEPT.

Law 6 The Materials Department will receive full credit for all blunders whether made by it or by someone else.

Actually, it can rarely be proved that a wrong material was recommended. All service or fabrication failures are the result of errors in materials selection, design or fabrication, or a combination of these factors. Before you accept in your own mind the diagnosis of improper materials selection, review your own recommendations and then ascertain whether the cause of failure might not be another factor such as improper heat treatment, sloppy workmanship or poor design. You may be able to prove the blunder was another department's responsibility. But it doesn't pay to publicly establish your innocence if it means making an enemy of someone you depend upon for your work load. A preferable method of showing management that your group is not really that stupid is a confidential memorandum giving them your slant on the matter. You may also find it desirable to privately give your diagnosis to the responsible designer or engineer. This step should help avoid a similar difficulty later on.

Law 7 The value of the Materials Department to the company will be inversely proportional to the amount of credit it claims for its contributions.

This law is obvious by now, but it implies an important corollary. Since a normal channel for promoting job satisfaction is shut off in the best interests of the company, it is up to the manager of the Materials Department to let his staff members know they are appreciated. If your group suffers from low or indifferent morale, check this vital point first.


MATERIALS DEPT.

Law 8 The Materials Department, if it does its job right, will be unpopular both inside and outside the company.

The problem is to minimize this unpopularity, and skill in human relations is important. The most important rule is: don't get personal. When altercations arise, always argue about "it", never about "you" and "me". You can also avoid many misunderstandings by making your presentations of data so clear and precise that they speak for themselves. Remember that what your data show may not be as obvious to others as to you.

Law 9 The Materials Department will occasionally be by-passed to its great distress.

But let it pass. If a wrong move has been made and you have not been consulted, it would certainly be unreasonable to hold you responsible. A blunder will eventually come home to roost. However, it would be well to have a memorandum in your file predicting trouble and marked for a followup to make certain that the opportunity for learning a lesson is not missed. Meanwhile, remember that the Materials Department is only one source of information for the designer or engineer. He may have better information than you have given him or could give him. Usually he knows what he's doing.

Law 10 The Materials Department will never be able to get a rational definition of either the areas of its influence or the extent to which it ought to influence other departments of the company.

The vague boundaries are nothing to be unhappy about. If your group is good, you can do that much more good. If your group is not so good, you will do that much less harm. If the manager has the respect and confidence of his associates, and the group has an attitude of service, your influence will gradually come to be all that it should.

Adapted from a paper presented at the second Basic Materials Conference, May 19, 1954 in Chicago.

What a Materials Department May Do . . .

1. **Sample and inspect all incoming materials according to some established procedures.**
2. **Prepare procedures for sampling and inspection of incoming materials.**
3. **Specify standard practices for proper handling and processing of acceptable raw materials.**
4. **Advise on or be responsible for plant troubleshooting.**
5. **Establish intermediate and final inspection criteria and procedures for materials components in products.**
6. **Prepare materials specifications for purchasing and keep them up to date.**
7. **Accept or reject materials with respect to specifications on materials properties (as opposed to tolerances on dimensions), or advise on their acceptance or rejection.**
8. **Assign specification numbers for materials to engineering drawings, and note appropriate heat treatments and processing instructions.**
9. **Advise on or be responsible for proper selection of materials.**
10. **Advise engineering and design departments of materials properties.**
11. **Monitor literature constantly for improved materials.**
12. **Send for manufacturers' literature and request samples and special data.**
13. **Interview salesmen and stimulate suppliers to do additional test work.**
14. **Test samples and make trial applications.**
15. **Publish data obtained both from company tests and from the supplier so that all parties concerned within the company may have ready access to them.**
16. **Work on the development of specialized materials to meet certain needs of the company.**
17. **Encourage and stimulate other companies to apply their research talents to the solution of specific problems.**
18. **Make comparison tests to determine better products and supply the purchasing department with a list of approved sources.**
19. **Advise on substitution of materials.**

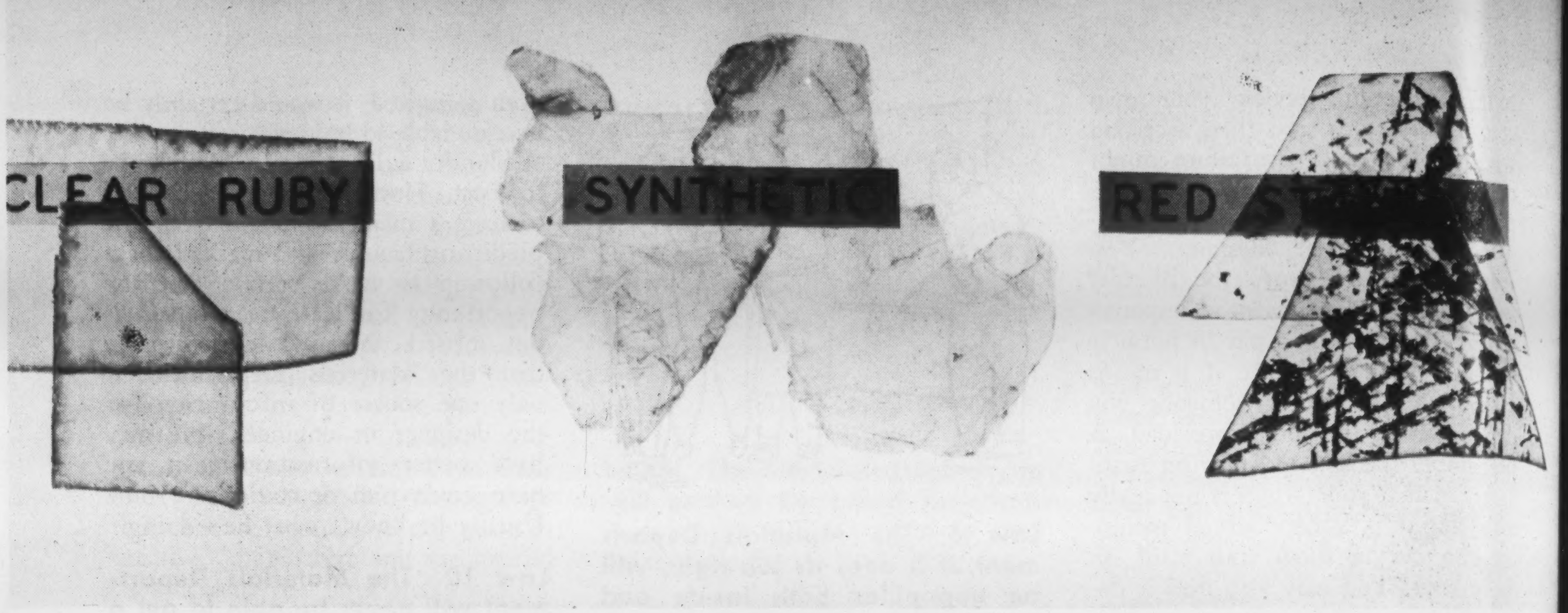


Fig 1—Crystals of natural and synthetic mica show the comparative clarity of synthetic fluor-phlogopite mica. Synthetic crystals of this size (approx 2 in. in max dimension) are very rare.

Toward Better Insulating Materials—

Three Forms of Synthetic Micas

1. **Molded with glass**
2. **Calendered into sheet**
3. **Hot pressed into blocks**

by THEODORE B. MERRILL JR., Assistant Editor, Materials & Methods

● DURING WORLD WAR II the shortage of sheet mica (the best of which is imported from India) spurred development work on synthetic production of the material in the United States. The Bureau of Mines' Norris Electrotechnical Laboratory developed a successful pilot plant operation in 1947, which produced crystalline mica from batch materials. The synthetic fluor-phlogopite mica produced in the pilot operation proved to have properties sufficiently superior to natural mica to warrant commercial production, and the Mycalex Corp. of America is completing the first facilities for commercial synthetic mica production, which will be able to supply industry with larger quantities of the new engineering material.

While synthesis of mica from its basic chemical constitutents achieves a purer, more heat-resistant material, very little of the synthetic production in the near future will result in crystals large enough to be used in most electronic applications of crystalline sheet mica. The bulk of a melt of synthetic mica is in the form of small flakes and microscopic crystals. These crystals, when consolidated, provide mica-based materials of the following three forms, each of which has unique characteristics: 1) bonded with glass in a Mycalex formulation, synthetic mica provides a more heat resistant material with more consistent electrical qualities; 2) as a pure mica reconstituted sheet it permits higher operating temperatures in electronic applications; and 3) as a hot pressed solid it is a promising insulating refractory with very good electrical and mechanical properties.

Natural and Synthetic Mica

Natural mica is a silicate of aluminum and potassium with hydroxyl (and sometimes fluorine) ions in the complex molecule. Natural mica also contains varying amounts of magnesium, iron, or lithium, which affect its electrical properties. Mica molecules are flat hexagons which join at their edges to form the flat plate crystals familiar as isinglass and capacitor dielectrics. The crystals have perfect basal cleavage and theoretically can be split into sheets one molecule thick, or any multiple thereof. In synthesizing mica, it is possible to replace any of the cations in the mica molecule, in whole or in part, with various other cations. Several hundred micas have been synthesized, but because of production difficulties in crystallization, commercial production is presently focused on fluor-phlogopite, which crystallizes at atmospheric pressure and exhibits most of the superior qualities of synthetic micas.

In fluor-phlogopite, fluorine is substituted for the hydroxyl radical contained in the mineral, resulting in a material much more resistant to high temperature. The breakdown of the hydroxyl groups in natural mica is the chief cause of swelling, bloating, and exfoliation.

Of the three forms of synthetic mica presently under investigation, only hot pressed mica powder is actually a new engineering material. The other two forms, reconstituted sheet and glass-bonded mica or Mycalex have sufficiently improved properties to widen their range of usefulness, but they are basically similar to compositions utilizing natural mica scrap.

Synthetic mica crystals are rare in sizes larger than 2 in., and are much more expensive than natural mica crystals. The synthetic crystals are clear as glass, have excellent electrical properties, are more easily degassed, and have much better high temperature resistance than natural micas, so they may find some applications in specialized precision electronic tubes where cost is unimportant compared to considerations of purity and resistance to high temperature.

Glass Bonded Mica

Finely powdered mica compounded with lead borate glass provides a structural insulating material with properties spanning the gap between the organic plastics and fired ceramics. Known since 1919, glass bonded natural mica has been progressively improved, and is now widely used in precision electronic equipment. Moldable in both transfer-injection and compression equipment, the material has excellent dimensional precision and stability and does not shrink during or after molding or as a result of aging.

The compression-molded grades of glass-bonded mineral mica are machinable with standard metalworking equipment and carbide tools.

The material is impervious to water, oil, and organic solvents; has high arc resistance (250 ASTM seconds); is completely free from carbonization under arcing; has a lower loss factor at high frequency (0.014 at 10^6 cps) than most insulating materials (exceptions are polystyrene, Teflon, and some electrical glasses); has dielectric strength in or above the range of the best insulators; and has a tensile strength of 5000 to 7000 psi and compressive strength of 23-27,000 psi.

One of the most useful properties of glass-bonded mica from a fabrication point of view is its thermal expansion coefficient. Being almost identical to that of mild steel, metal inserts can be molded in place and remain tightly bonded over a wide range of operating temperatures. The best grades of glass-bonded natural mica have operating temperature limits of 650 to 700 F.

The substitution of synthetic fluorphlogopite mica for natural mica in glass-bonded material results in a general improvement of all properties due to the higher purity, greater temperature stability, and absence of hydroxyl radicals in the mica molecules. Heretofore, a serious limitation on the mechanical and fabrication properties of glass bonded mica at high temperature has been the necessity of using low melting point glass. Since a mixture of glass and natural mica will break down at high temperatures into a vitreous ceramic of mediocre electrical characteristics, definite limitations are placed on the type of glass used and the temperature to which the mica-glass mixture can be heated to secure plasticity needed in molding operations. The mixture of glass and mica is further complicated because the final material is not merely a dispersion of mica particles in glass; there exists a chemical bond between the glass and mica particles which results in the material's strength and good electrical characteristics.

Glass bonded synthetic mica can be differentiated visually from natural mica compositions, as it is almost snow white, while natural mica compositions are green to brown in color.

At present, glass bonded synthetic mica is compounded of the same low temperature glasses used with the natural micas, but the increase in refractoriness and machinability of the material is striking.

With the same glass base, the heat resistant properties of compression molded and injection molded grades of natural and synthetic mica compositions compare as follows:

	Natural Muscovite Mica	Fluor Phlogopite Mica
Compression molded	650F	800F
Injection molded	700F	900F

(Temperature without heat distortion effects.)

When samples of the four grades of material are subjected to a temperature of 1100F, the difference in refractory behavior is obvious. Fig 4 shows two sample bars of synthetic and natural mica based injection molded Mycalex before and after heating to 1100F. Notice that the material containing the natural mineral bloated and broke down completely at this temepratture due to the release of water vapor from the hydroxyl radicals contained in the natural mica. The synthetic product lost strength and sagged under its own weight, but did not suffer bloating.

Fig 5 shows two sample bars of compression molded Mycalex of identical composition except for the substitution of synthetic for natural

Fig 2—Synthetic mica crystal is pure white, transparent as window glass, and is slightly more difficult to split than natural mineral grades of mica. Crystals of this size are not available commecially.

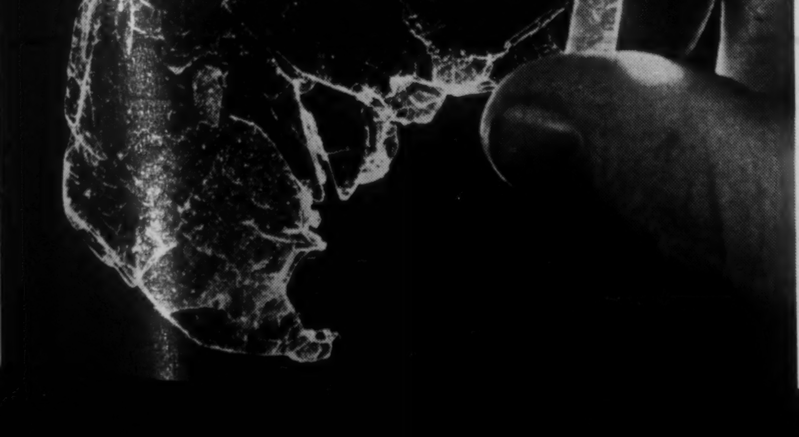
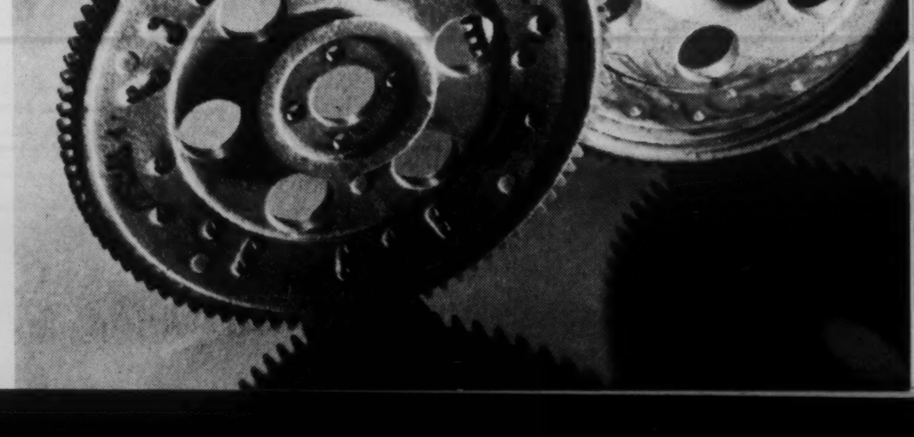


Fig 3—Glass bonded synthetic and natural mica gears have integrally molded steel rims and metal threaded inserts. Gear in front was injection molded of natual mica Mycalex, while white gear in rear has synthetic fluor-phlogopite base.



mica. After heating to 1100F the natural material expanded 15% in the direction of compression, while the synthetic material swelled less than 1%. It must be emphasized that the same glass was used with the synthetic and natural mica and both groups of samples heated beyond their design range. Research is underway to develop formulations of glass-bonded synthetic mica using higher melting point glass, and indications are favorable that operating temperatures ranging from 1200 to 1500F will be possible in the near future.

Another important property difference is the increase in machinability of the synthetic mica formulations. Compression molded grades, containing a larger proportion of mica to glass than the injection molded types, are machinable in either synthetic of natural formulations—the synthetic being somewhat superior. Injection molded grades of natural mica, on the other hand, are not machinable, while the same composition, substituting synthetic for natural mica, is machinable due to increased purity and perhaps some change in the bond structure.

The higher temperature stability and greater machinability of synthetic mica and glass ceramoplastics promise to broaden the usefulness of these materials. For example, it is possible to injection mold contact pins in a flat plate of the material, then print circuits in silver paste on its surface and bake the entire assembly at temperatures up to 900F without endangering physical or electrical properties or altering the dimensions of the piece. Higher temperature solders and brazing alloys can also be used on printed circuit plates of glass-bonded fluor-phlogopite.

Reconstituted Sheet

A second form of synthetic mica is reconstituted sheet (sheet mica made from small flakes). Good electrical quality reconstituted natural mica sheet is manufactured by several concerns using organic or silicone binders, but it is subject to the temperature limitations of both the binding medium and the natural mica. Natural crystalline sheet mica subjected to excessively high temperature exfoliates and exudes water vapor. Either effect can make a vacuum tube inoperative.

Synthetic mica, on the other hand, does not give off water vapor and is much more resistant to temperature. Thermal breakdown of natural mica occurs between 1200 and 1400F, while the fluor-phlogopite exists with little or no deterioration in a dry atmosphere at 1500F and shows only slight decomposition when exposed to temperatures over 1800F for a few minutes. Successful fabrication of synthetic mica sheet would, therefore, not only provide a better high temperature material than is now available for electronic tube spacers, resistance boards, and other parts subjected to high temperatures, but it would free the U.S. of dependence on foreign sources for sheet mica.

While no one has yet succeeded in devising a practical method of producing a completely non-porous reconstituted mica sheet satisfactory for dielectric applications, the Product Development Laboratory of Sylvania Electric Products, Inc. has worked out (under contract to the Navy Department Bureau of Ships) a successful method of producing an all fluor-phlogopite reconstituted sheet with excellent high temperature characteristics.

Final evaluation of the reconstituted sheet is not yet complete, but preliminary reports are most encouraging. At the very least, development is assured of a material capable of withstanding temperatures 400 to 500F higher than natural mica.

The Sylvania reconstituted sheet is made from small (60 mesh and over) crystals of fluor-phlogopite bonded together without a foreign binder. The single component material has a modulus of rupture between 10,000 and 15,000 psi., about 1/5 that of natural mica at room temperature. The sheet is porous, but it is homogenous—it rings when struck.

The Sylvania-Bureau of Ships research is centered on perfecting a material suitable for high temperature use as spacer elements in vacuum tubes. The Sylvania Laboratory has produced uniform sheets in disk shape with a thickness of 0.010 to 0.015 in. It is possible to produce thicker or thinner sheets. Fabrication properties of the synthetic sheet permit precision parts such as tube element spacers to be produced by punch press techniques.

Advantages of the synthetic mica sheet, besides its higher temperature resistance, include easier degasification, and absence of water vapor formation at temperature and exfoliation as thermal breakdown temperatures are approached. It is a highly promising material for electronic applications in vacuum at high temperature and as a resistance wire

Properties of Hot-Pressed Synthetic Fluor-Phlogopite Mica

	Normal Fluor-Phlogopite	Boron Fluor-Phlogopite	Barium Di-Silicic	Barium Lithium Di-Silicic
Formula	$KMg_3Al\text{-}Si_3O_{10}F_2$	$KMg_3B\text{-}Si_3O_{10}F_2$	$BaMg_3Al_2\text{-}Si_2O_{10}F_2$	$BaMg_2AlLi\text{-}Si_3O_{20}F_2$
Theoretical Density, lb/cu in.	0.103	0.102	0.124*	0.120*
Hot Pressed Density, (% theor)	96	96.5	95.7	99
Water Absorption, %	0–1	0–1	0–1	0–1
Softening Temp, F	2000–2200	1650–1850	2000–2200	1650–1850
Melting Point, F	2450	2450	2550	2550
Thermal Stab. Limit for constant use, F	1475	1475	1475	1475
Hardness (Mohs')	2–3	2–3	4–5	4–5
Linear Coef Exp, (in./in./Fx10^{-6} 70-1100 F)	7.0	7.0	4.4	—
Machinability (turning)	good	excellent	poor (can be ground)	fair
Power Factor (1MC)	0.001	0.0007	0.0003	0.0004
Constant (1MC)	6.3	5.93	7.6	7.88
Loss Factor (1MC)	0.0063	0.004	0.0022	0.0032
Bending Strength, psi	7500	7500	7500	—
Approx Rupture Strength, psi, at:				
75-750 F	11,000	—	—	—
75-1100 F	6000	—	—	—
75-1475 F	1200	—	—	—
Dielectric Strength	400v/mil	400v/mil	—	—
Approx Thermal Cond, ft/btu/sec/sq ft/°F/ft, at:				
575 F	—	1.2342	—	—
800 F	—	1.3310	—	—
1050 F	—	1.2520	—	—

* *Approximate.*

(*Brush Beryllium Co.*)

support medium in applications where natural mica is subject to thermal failure.

The price of the synthetic material will undoubtedly be higher than natural mica for small parts, but eventually it may well be competitive with large sheets of electrical quality mica, which cost as much as $100 per lb in sizes around 6 x 8 in.

Hot Pressed Mica

As often happens as a corollary of attempts to synthesize a material in a specific form, the research effort devoted to producing synthetic mica crystals at Norris Electrotechnical Laboratory resulted in the discovery of a form of mica which has promising characteristics as a new engineering material. This new material is produced by hot pressing finely powdered synthetic mica into a homogenous block. The resulting compact is a dense, ceramic-like dielectric material which is soft and machinable, yet has transverse strengths of more than 8000 psi at temperatures up to 750F.

Since the production process of hot pressed mica utilizes extremely fine particles of mica, raw materials are not limited to mica formulations which form large crystals. As a result, the producers of hot pressed mica can take advantage of the extensive ionic replacements which are possible in the synthesis of mica and which permit far greater variations in the properties of the material than is possible with other ceramic materials.

The Brush Beryllium Co, under a research contract with the Office of Naval Research, is currently producing semi-production quantities of the four micas listed in the table. All four of the micas listed are prepared from readily available raw materials, and are available in test quantities in either powder or block form.

Hot pressed mica is fine grained, dense, weather resistant and mechanically strong. It has the inherent softness of natural mica, and can be machined to exceedingly close tolerance. Machining the material is the last production operation, and no further firing is necessary. It should be a satisfactory alternate material for block talc. It is an excellent insulating material at both elevated and room temperature. Its dielectric constant varies little with temperature, most compositions changing less than 5% when heated to 750F. The power factor remains less than 1% up to 550F.

Cost, Availability, Outlook

At this time it is difficult to estimate cost figures due to the lack of large scale production of any synthetic mica products. Due to the higher cost of raw materials, synthetic mica glass bonded materials will be more expensive than natural mica compositions. If large scale production of reconstituted sheet is undertaken, the cost of larger sheets of synthetic mica will probably be lower than large sheets of high quality electrical grade natural mica. Final cost figures on hot pressed micas await larger scale production.

There exists an important relationship between the forms of mica used as crystals and as powder in terms of raw material production techniques. The corrosive nature of molten mica and the material's high melting point make it necessary to melt the material electrically in the center of a large batch of basic chemical mixture. This produces an area of totally molten mica surrounded by a sintered mass of microscopic crystals. The center mass crystallizes into flakes (in the case of fluor-phlogopite) surrounded by the solid sintered material, the whole melt resembling the geological formation known as a geode. With the development of hot pressed mica block material, the sintered crystals are useful as well as the crystallized central melt, which should help to reduce costs by eliminating scrap waste.

The progress in synthesizing mica represents considerable success in gaining several hundred degrees more temperature resistance for structural insulating materials. The personnel associated with the basic research on synthetic mica feel unanimously that many more micas with useful engineering characteristics are now within reach and will result in considerable increase in the dependability and operating efficiency of many electrical and electronic devices.

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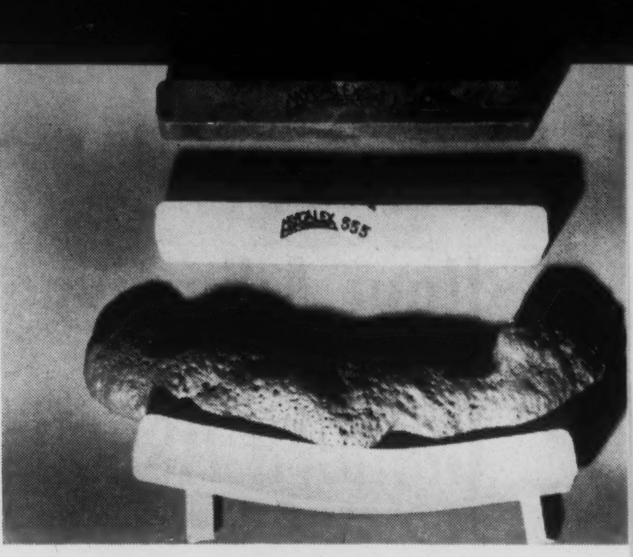


Fig 4—Injection molded natural and synthetic mica Mycalex behave differently when heated to destruction. Two top bars show original form. Bottom specimens show condition after heating to 1100 F. White bars are synthetic; dark bars are natural mica based; both have same proportion of mica to glass. Note how natural mica specimen bloated and foamed, while synthetic based material merely lost strength and sagged.

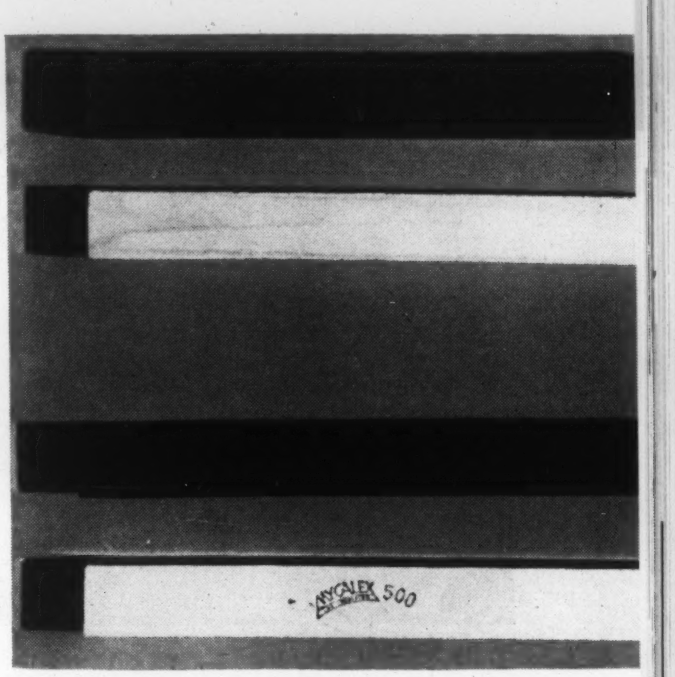


Fig 5—Compression molded natural and synthetic Mycalex specimens before (below) and after (top) heating to 1100 F. Natural mica based material "relaxed" and expanded 15% in direction of compression, while synthetic material expanded less than 1%. White specimens are Mycalex 500 synthetic mica based material.

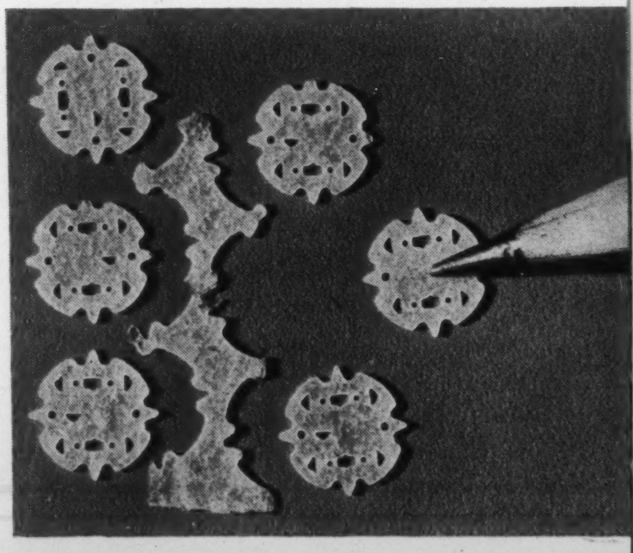


Fig 6—Tube element spacers of reconstituted synthetic mica sheet withstand higher temperature than natural mica crystals. Thickness of sheet is easily controlled during manufacture, giving it an advantage over natural mica crystals, which are difficult to split to precise dimensions.

How Adhesives Solve Camera Assembly Problems

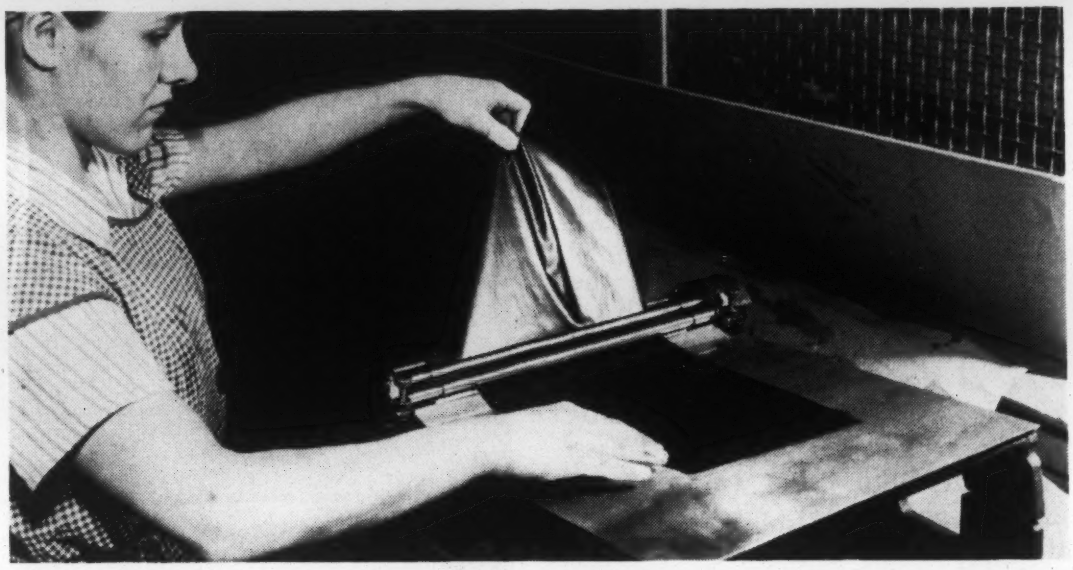
Rubber base adhesives successfully join many different materials combinations such as rubber-to-metal, plastics-to-metal, and plastic coated cloth-to-metal.

In assembling its cameras, Graflex Inc. finds that rubber-based adhesives offer decided advantages in strength, appearance of the finished part and lower assembly costs. Joining operations involve a variety of materials including plastics, vinyls, metals, rubber and wood.

Welding is used on some operations but particularly on aluminum parts, does not in every case produce satisfactory assemblies. Animal glue has been tried on several operations but its performance was unsatisfactory.

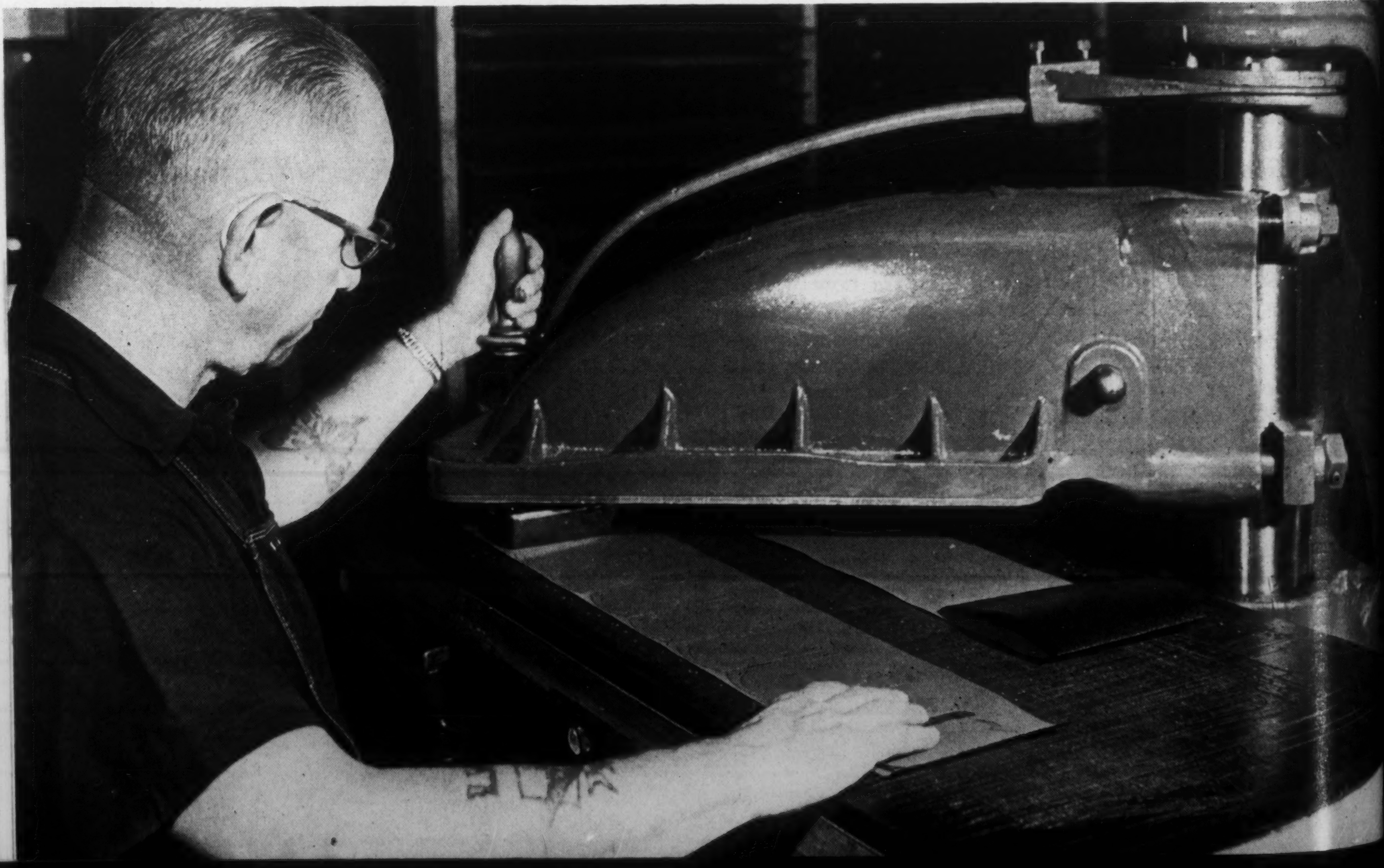
Poor water and oil resistance of the animal glue made it unsuitable for the finished product. Assembly costs were high since the glue did not adhere to painted metal, and the areas to be bonded either had to be masked off before painting or the camera parts had to be painted by hand after the gluing operation. Covering materials had to be die cut before the glue was applied just prior to the actual joining operation, since the glue could not be reactivated. These and similar related factors added up to make the assembly operations far too costly.

Engineers at Graflex in consultation with the Adhesives and Coatings Div., Minnesota Mining and Manufacturing Co. selected several rubber based adhesives that overcame previ-



Diluted rubber base adhesive being applied with roller coater to back of cellulose nitrate cloth.

Die cutting cellulose nitrate coated cloth to which adhesive was applied previously and allowed to dry. This sequence of manufacturing steps is far more ecomonical than coating after die cutting.



ous difficulties and enabled quality products to be produced while keeping costs in line. Several adhesives are used since operations include joining many combinations such as vinyl coated cloth to metal, rubber to metal, metal to metal, and vinyl to metal.

For bonding cellulose nitrate coated cloth to a phenolic resin (Mahoganite) camera case to give a leather appearance, a synthetic rubber based adhesive is applied to the cloth. Two coats are applied by roller to sheets of coated cloth that is also used for making camera bellows. The solvent in the adhesive causes the coated cloth to curl slightly, so the pieces are tacked to a wood board as soon as the adhesive is applied and remain there until the solvent flashes off in 2 to 3 min. Once dry, the cloth is stored until it is needed.

For the actual bonding operation, the camera case is wiped clean with a rag dipped in toluol. The adhesive on the back side of the die cut covering material is wiped with a brush dipped in toluol and allowed to reactivate the adhesive, becoming tacky. A second brush application of toluol is made 5 sec before the bond is completed to insure transfer of the adhesive and facilitate positioning of the piece to the case. The coated cloth is pressed into contact under hand pressure with special hand tools in order to make edge contact since the bond is made in a slight recess in the case.

Wooden camera cases made of Hondurus mahogany are sprayed with a rubber based adhesive and the vinyl coated cloth used is sprayed with the same adhesive in a separate operation. Recessed sections of the case are masked during spraying.

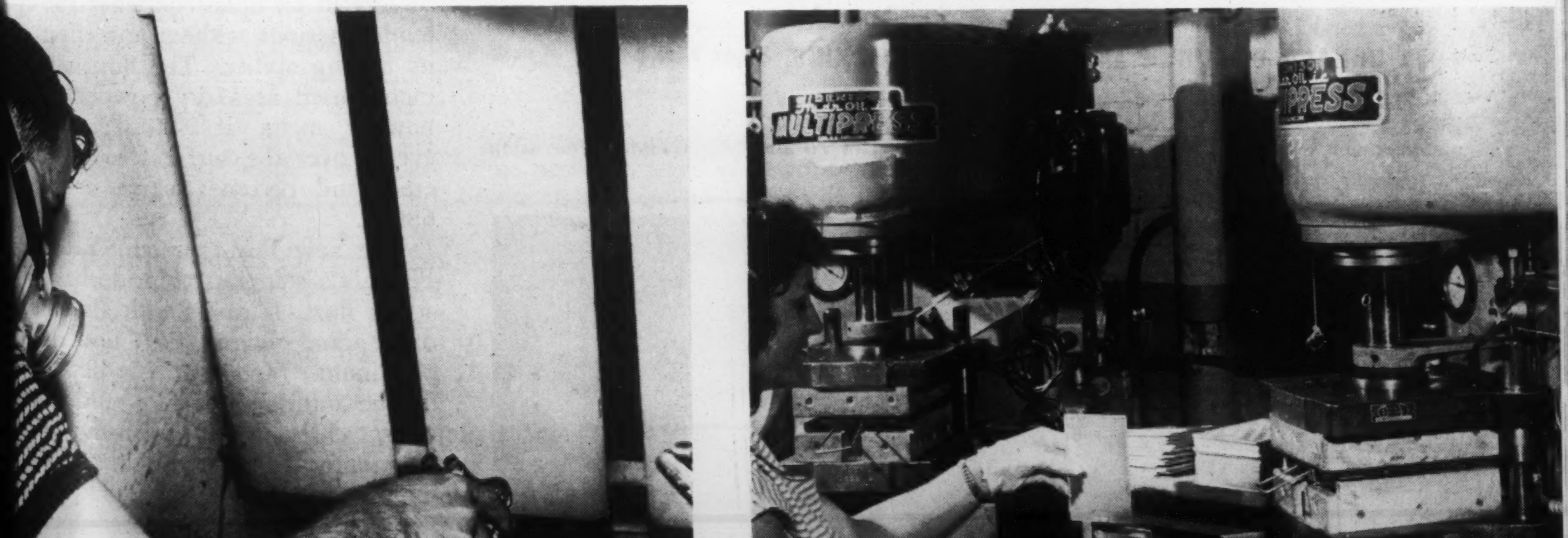
Although the adhesive bonds tightly to itself when dry, the adhesive on the vinyl coated cloth is brushed with toluol about 1 min before bonding to give the adhesive a slight tackiness and insure a 100% bond. After the bonding operation is completed by hand, the entire case is put into a special fixture. Here uniform pressure is applied over the entire case, insuring the bonding of areas that may have been missed during the hand operation.

Metal-to-metal bonding in making up film holders uses a light colored, high strength, oil resistant adhesive. Anodized aluminum is the metal used to make up the holders. Flat metal plates, called septum, are sprayed at an atomization pressure of 65 psi. The gun is held close to the work and the plates get a smooth, uniform coat.

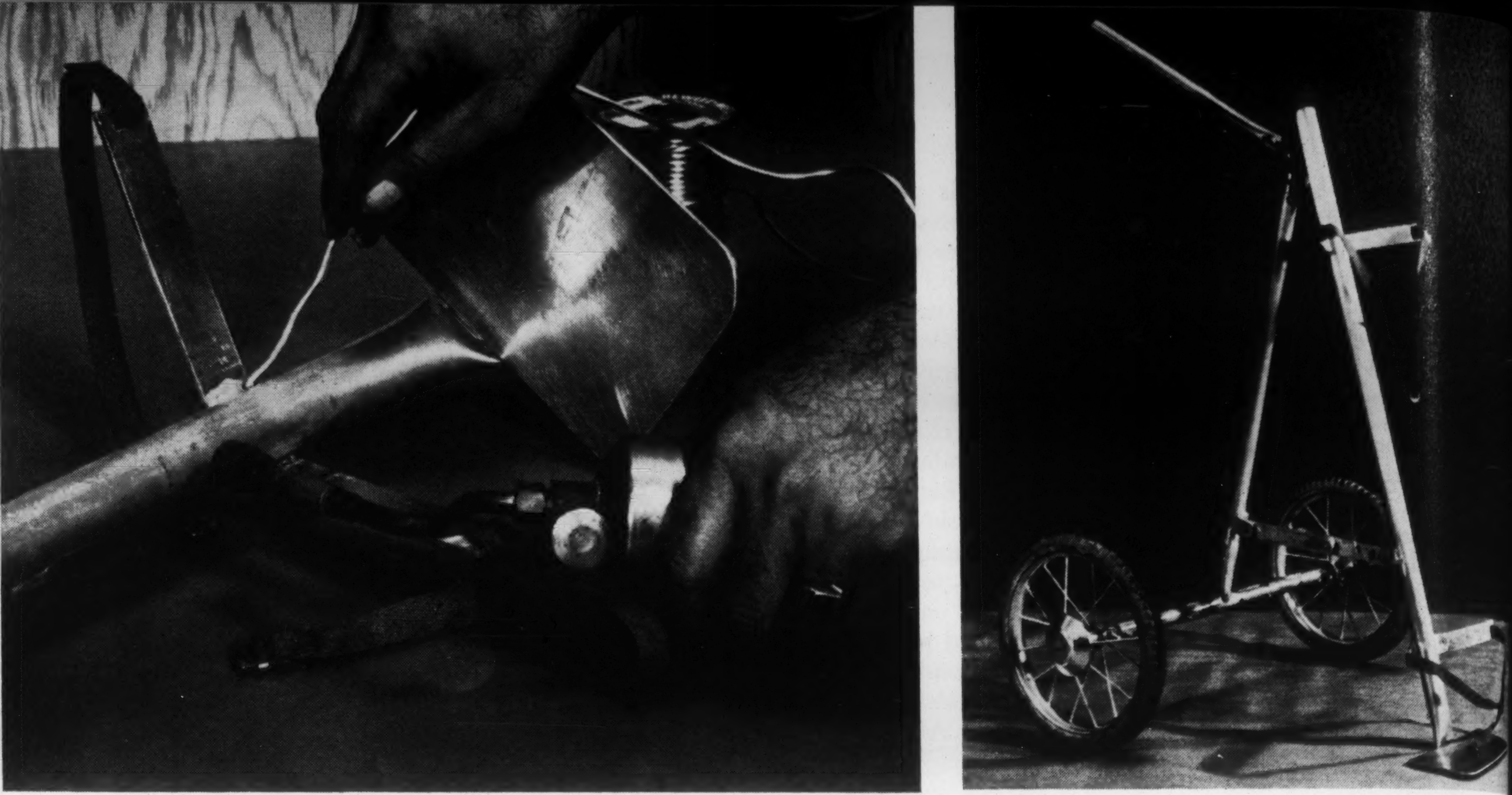
Heat reactivation bonding is used to join the two septum plates to an anodized aluminum core (perforated metal). A jig automatically lines up and positions the parts. The pieces are then clamped and a 1-in. dia spot is heat reactivated for 7 sec at 200 F. This spot merely holds the pieces together while the operator moves them to larger, automatically controlled presses that exert over the entire bonding area a 200-psi pressure for 1 min at a temperature of 275 F. The assemblies are then removed and placed into racks for further processing into film holders.

A dark curing type oil resistant adhesive is used for several operations. For example vinyl used on face plate assemblies is precoated, allowed to dry for 8 to 24 hr, cut to shape with steel dies, and finally bonded to the metal face plate in a clamping jig. Only the vinyl is coated, no adhesive is applied to the face plate.

This same adhesive is used as a precoating on operations involving the bonding of velvet and felt to metal. The cloth is die cut after the adhesive dries. At the time of joining the cloth to metal, the adhesive acts as a sizing material preventing the wet coat of the joining adhesive from bleeding into the cloth and starving the glue line. Also, during die cutting, the sized material does not fray.



Spraying anodized aluminum plates with rubber based adhesive (left). Plates, known as septums, are given two coatings of adhesive, dried, then placed in fixture (right) that lines them up with the core. Heat and pressure are first applied to small spot in center to make temporary bond. They are then placed in a large press.



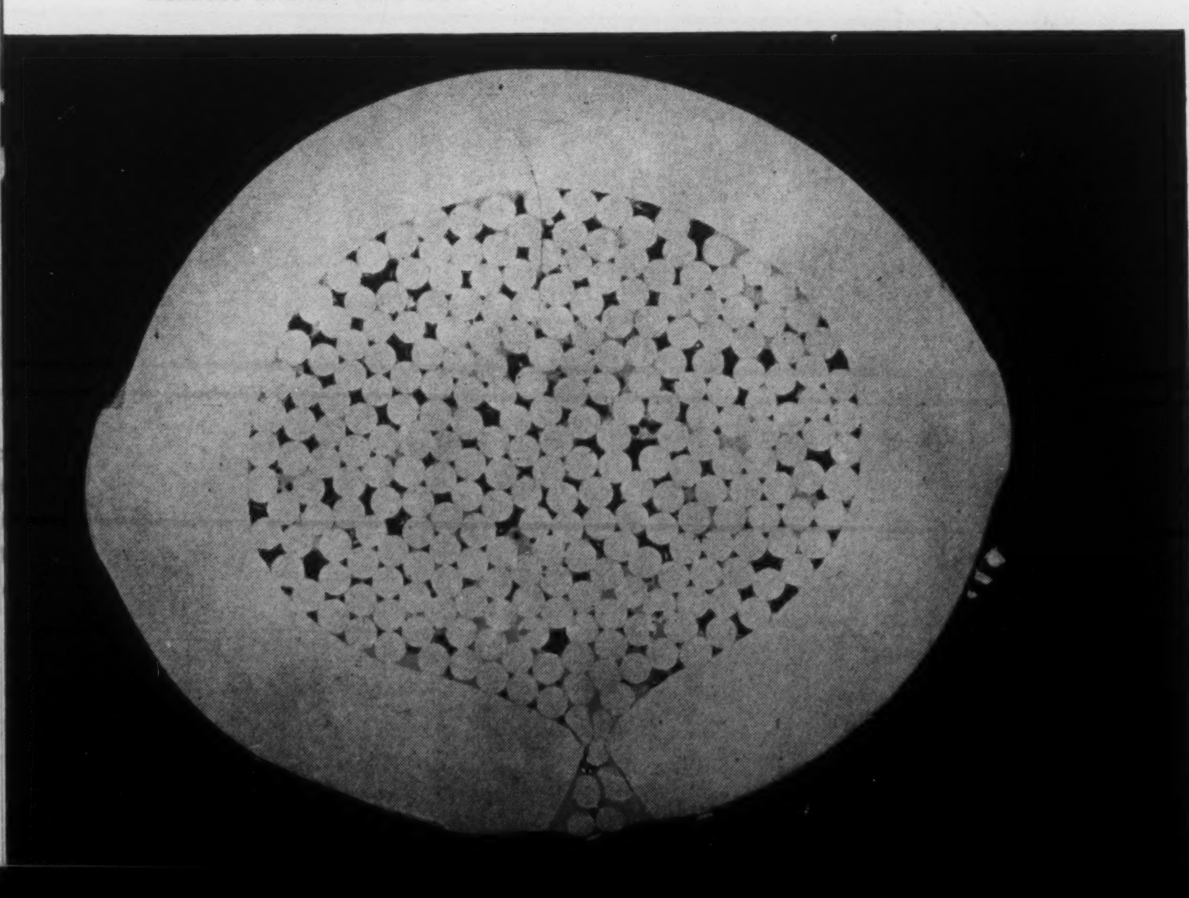
New flux is used successfully in soldering joint on golf caddy.

New Tin-Depositing Flux for Soldering Aluminum

A stannous chloride base reaction flux used with zinc-tin or zinc-aluminum alloys meets most requirements for successful soldered joints in aluminum.

by **DONALD C. BURCH** and **ROBERT L. SIMPKINS**, Essex Wire Corp.

Aluminum cable with brass lug joined by dip coating in 70 zinc-30 tin solder after using stannous chloride base flux.



● ALUMINUM IS difficult to solder because a tenacious skin of oxide covers exposed surfaces at all times. The common fluxes for lead-tin solders on brass or steel are useless on aluminum. Moreover, the lead-tin solders, in contact with aluminum, set up galvanic junctions which cause the aluminum next to the joint to corrode in moist atmospheres. Now, a new flux has been developed which, when used with zinc-tin or zinc-aluminum solders, meets most of the requirements for a good flux on aluminum. The flux is not hygroscopic, and may be left in an open container for extended periods without any effect on its fluxing ability. The flux is commonly used as a dry powder. This powder melts at 380 F, spreads evenly over the surfaces to be soldered, and becomes active at about 680 F.

The new flux, named SXAluma-Flux, is a stannous chloride base reaction flux. It reacts with aluminum oxide and with the underlying aluminum. Metallic tin is deposited on the aluminum surface, and aluminum chloride is formed. This aluminum chloride volatilizes, leaving no corrosive residue. However, if an excess of flux has been applied and has not decomposed, the excess is easily washed away with water. The tin that is deposited on the aluminum surface temporarily prevents the formation of a new layer of aluminum oxide, and then alloys readily with both the aluminum and the solder. Normally, the small amount of tin deposited has little effect on the properties of the soldered joint. The flux and a suitable solder make excellent butt joints and lap joints between aluminum bars, sheet, and plate. Also, it makes possible fabrication of excellent electrical connections on aluminum wires and cable. Probably, because of entrapment of flux decomposition products, it would be unsatisfactory for joining large flat surfaces such as laminated plates.

Although the flux is normally used as a powder, it may be kept molten for more convenient use. It has been maintained molten at 450 F for three weeks without noticeable effect on its fluxing ability, and with but minor change in composition. However, slow oxidation of the flux takes place under these conditions.

Properties of Soldered Joints

Experience has shown that zinc-tin alloys with from 20 to 90% of tin, and zinc-aluminum alloys with about 5% of aluminum make satisfactory joints when applied with this flux. For several reasons, the 70 zinc-30 tin alloy has been selected as offering the best over-all combination of properties and convenience in application.

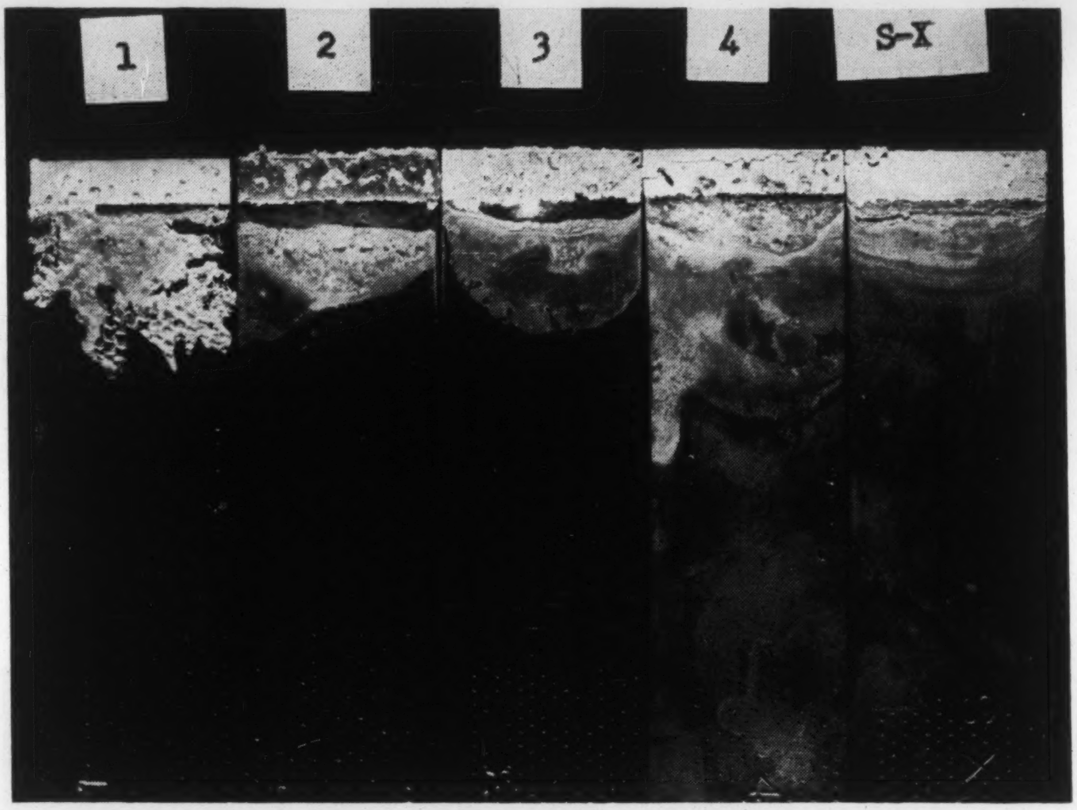
Joint Strength—A soldered joint may be stressed either in tension, torsion, or shear, or in combination of these. Shear failures are probably the most common type. Half-inch-square bars were butt welded and broken to learn the tensile strength of the soldered joints. In addition, joints in 0.064-in. thick sheet, cut to 0.860 in. wide and lapped exactly 3/16 in. were made to determine shear strength and corrosion resistance. (Strictly, the values shown are "lap joint" strength, since some deformation of the joint takes place when thin laps joints are pulled in tension.) The average strength of 15 specimens of each type, joined with 70 zinc-30 tin solder, are given in the table.

Butt joints in 1/2-in. dia. rods of 2S aluminum were wrapped around a 1-in. mandrel without any sign of cracking. Joints in this material, being stronger than the stock, could not be broken, either as butt or lap joints.

Strength of Lap Joints

Flux and Solder	Strength, psi	
	3S Aluminum to Copper	Copper to Copper
1-A	5100	10,800
2-B	3100	6700
3-C	4300	7300
4-D	(2)	9600
Aluma-Flux(1)	(2)	9600

(1) *With 70 zinc—30 tin solder.*
(2) *Aluminum strips broke while joints held.*



Failed copper-to-copper soldered lap joints showing effect of entrapped flux residues. Numbers correspond to those in accompanying table.

Corrosion Resistance—No laboratory method of determining corrosion resistance exactly reproduces the conditions encountered in actual service. Since service tests for corrosion may require years to complete, indications of probable service life are sought in the laboratory by accelerated tests. Therefore, fluxed and soldered joints were exposed in the laboratory to peratures, and to continuous salt-spray.

One group of aluminum specimens was soldered applying the solder with the stannous chloride base flux. For comparison, another group was made without any flux by using the solder to severely abrade the aluminum surface. All of these specimens were exposed in a cabinet maintained at 150 F and 100% relative humidity for four weeks. Five times in each week the specimens were removed from the cabinet for eight hours and allowed to dry in still air of 57% relative humidity at 85 F. Because all of these joints were stronger than the aluminum strip when first prepared, the original joint strength could not be determined. The information obtained from groups of 15 specimens of each type is summarized in an accompanying table.

Although at the end of the test the fluxed joints averaged somewhat weaker than the abraded joints, the difference was small. On examination the fluxed joints showed no more evidence of corrosion than the abraded joints. Hence, it was concluded that the new flux had an almost negligible effect on the corrosion rate.

The salt-spray corrosion test showed no deterioration in fluxed lap joints during the first 700 hr. After

1000 hr of exposure, the joint strength started to drop slightly. In this test, the specimens were sprayed continuously with a 20% solution of sodium chloride maintained at 95 F., the conditions specified for ASTM Test B-117.

Eelectrical Resistance—Aluminum battery cables, with aluminum lugs lightly crimped on, were plunged into a pot of 70 zinc-30 tin solder held at 750 F. Moments before, some Aluma-Flux powder had been thrown on the solder. After a few seconds, the parts were withdrawn and the excess solder was shaken off. The entire lug was coated with smoothly adherent solder and was firmly soldered to the cable. The cables were exposed to a salt spray (ASTM Test B-117) for 504 hr with the results shown in the table. For comparison, commercial copper wire battery cables having brass lugs coated with lead-base solders were exposed at the same time. It is obvious from these data that the aluminum cables were not affected any more severely than were the copper cables. Because of their greater hardness, the 61S lugs would be preferred to 2S lugs for practical applications.

Resistance of Battery Cables Exposed in Salt Spray Test

(20% sodium chloride maintained at 95F)

Solder	Cable	Lug	Cable Resistance, Ohms		
			As Prepared	After 336 hr(1)	After 504 hr(1)
70Zn-30Sn	EC Al	2S Al	0.000205 0.000204	0.000216 0.000205	0.000388 0.000270
70Zn-30Sn	EC Al	61S Al	0.000217 0.000218	0.000323 0.000247	0.000304 0.000276
Lead base	Copper	Brass	0.000280 0.000318	0.000360 0.000329	0.000397 0.000391

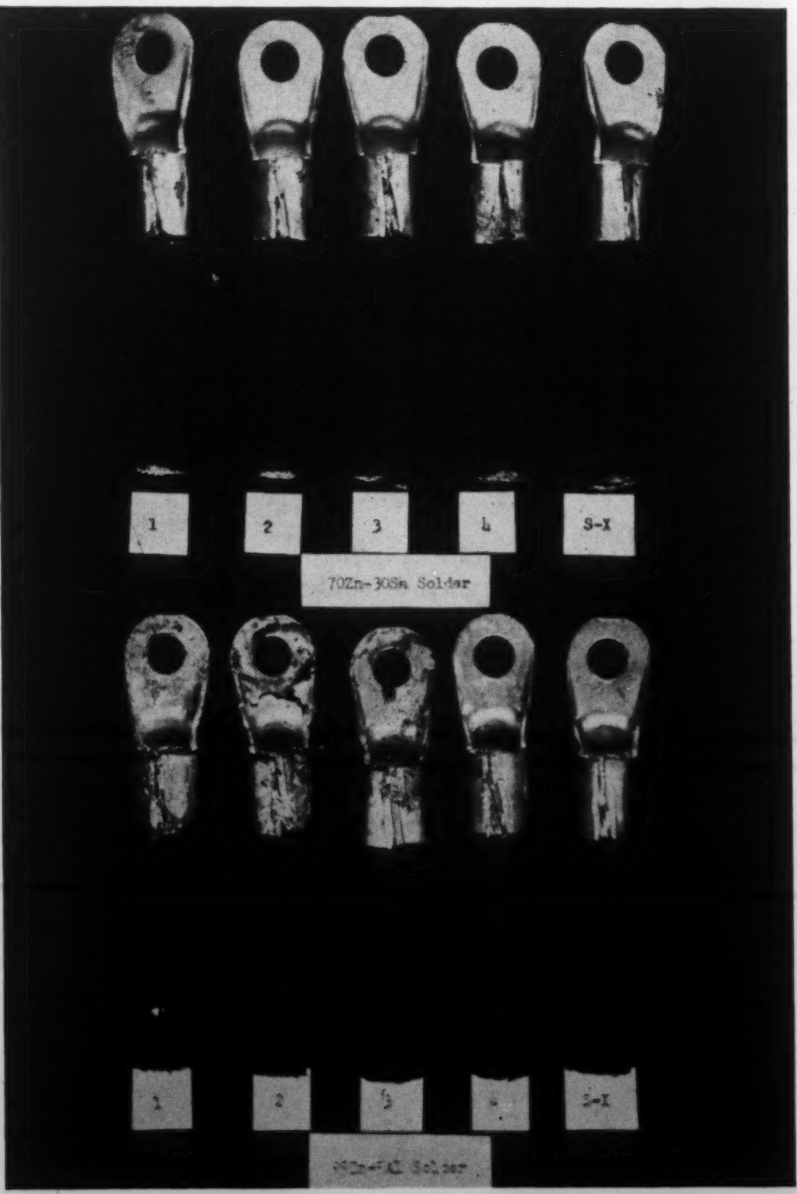
(1) *The cables were washed free of salt and dried before the resistance measurement.*

Comparison with Other Fluxes

Joints in 3S aluminum, which were made with various commercial solders and fluxes, were exposed to an accelerated corrosion test in the humidity cabinet. Conditions were identical to those of the previous test, but the exposure time was reduced to two weeks. At the end of this time, all but one of the joints made with other commercial fluxes and solders had fallen apart. The average strength at the end of the test, of groups of five samples variously fluxed and soldered, are shown in the table.

In addition to the aluminum-to-aluminum specimens used in the corrosion test, similar lap joints were made, joining 3S aluminum to copper, and copper to copper. The strength of these joints is shown in the table, and the appearance of some of the broken joints are shown in an accompanying photograph. Flux pockets are evident in most of the parted areas. Carbon-aceous residues were left by Fluxes No. 1, 2 and 3. Obviously, only the No. 4 flux was comparable to the stannous chloride base flux in fluxing ability on aluminum. Corrosion resistance of Aluma-Fluxed joint was superior.

Battery cable lugs were soldered with each of the five fluxes under examination and with two solders. The lugs could be joined with all of the fluxes and 70 zinc—30 tin solder, but three of the commercial fluxes left uncoated ends on the lugs. Another set of lugs was coated with each of the fluxes and 95 zinc-5 aluminum solder. Of the other commercial fluxes only the No. 4 had sufficient fluxing ability to make a reasonably good coating. Smooth, complete coatings could be obtained with either solder and Aluma-Flux. An accompanying figure shows these solder-coated lugs.



Dip-coated aluminum battery terminals made with various fluxes and 70 zinc-30 tin solder (top) and 95 zinc-5aluminum solder (bottom).

Methods of Application

The new stannous chloride base flux may be used in torch or furnace brazing, or by any other method in which sufficient heat is made available. Copious fumes are evolved, making good ventilation essential. Although irritating, these fumes are not toxic.

One method of attaching battery cable lugs has been described. Another method is to dip the cold, crimped on lugs briefly in a molten flux bath held at about 450 F. A thin coating of flux will freeze to the lug. After this, the lug may be plunged into the solder. Also, the lugs may be preheated in the solder pot, dipped into the powder flux, and then again into the solder pot. Whatever means is used, it is essential that the solder be hot enough to complete the operation in two or three seconds. Longer immersion times permit too much aluminum to dissolve in the solder, even at reduced temperatures. For the 70 zinc -30 tin solder, a pot temperature of 750 F is recommended. The pot should be large enough to stay hot when the cold lugs are introduced. The 95 zinc-5 aluminum solder requires a pot temperature of 800 F. Excessive build-up of aluminum in the solder pot has not been experienced *if the immersion time is sufficiently short.*

Although this new flux was developed specifically for use on aluminum, joints in cast iron, stainless steel, carbon steels, copper, brass, and monel were easily made with the flux and the recommended solders. These recommended solders required relatively high temperatures for their application. It is expected that the flux used with zinc-base solders, will find use on many materials where resistance to higher temperatures is required than can be tolerated by the common lead-tin solders.

Acknowledgements

The laboratory evaluation of the flux, including the determination of the mechanical properties of soldered joints and their resistance to corrosion, was made by Battelle Memorial Institute.

Strengths of Lap Joints in 3S Aluminum

Flux and Solder	Strength, psi	
	Before Corrosion	After Corrosion
1-A	3800	0
2-B	1800	650
3-C	1200	0
4-D	(2)	0
Aluma-Flux(1)	(2)	3400

(1) *With 70 zinc—30 tin solder.*
(2) *Aluminum strips broke while joints held.*

Strengths of Joints in 17S and 75S Aluminum

Material Joined	Joint Type	Stress Type	Strength, psi
17S Aluminum	Butt	Tension	28,600
75S Aluminum	Lap	Shear	10,100

Strength of Lap Joints After Four Weeks' Exposure to 100% Humidity at 150 F

Solder	Aluminum Alloy	Joint Strength Before Corrosion, psi	Joint Strength After Corrosion, psi	
			Fluxed Joint	Abraded Joint
95Zn-5Al	3S	5900(1)	4770	5060
70Zn-30Sn	2S	4400(1)	2560	2910

(1) *Aluminum strips parted near joints which did not fail.*

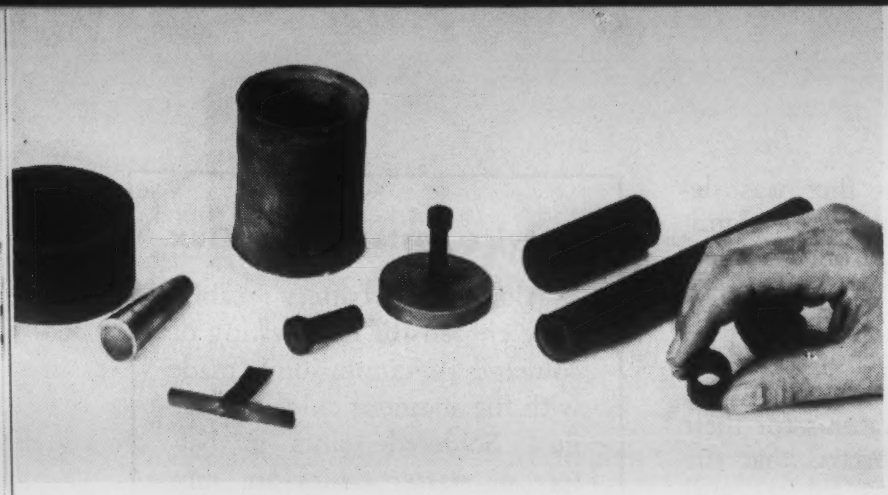
Service Tests of New Flux

Aluminum battery cables were chosen for field testing of soldered aluminum joints made with the stannous chloride base flux. Soldered joints in battery or starter cables are subjected to temperature extremes, moisture, grease, battery acid, and vibration. This type of service will quickly reveal faulty joints since the increase in resistance on the joint due to corrosion or mechanical failure of the joint will cause sufficient voltage drop to prevent the starter motor from operating.

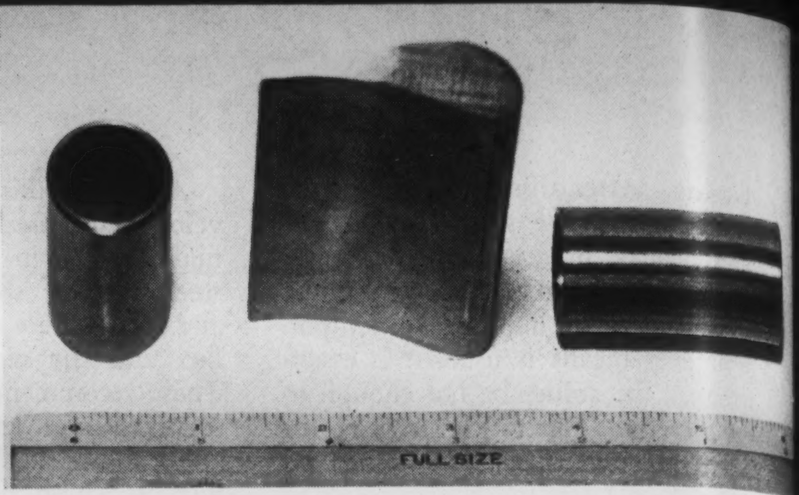
The major portion of the field testing program consisted of installing aluminum battery cable sets on over 300 cars distributed over the entire country. Each set contained three cables with two terminals each so that the number of soldered aluminum joints under test was over 1800.

A serial number was assigned to each cable assembly and the electrical resistance of the assembly was measured and recorded. The cables were then installed on the vehicles. These aluminum battery cable assemblies went into service early in February, 1952. Service reports have been received on the cables every 60 days since installation, and no failures have been reported as yet.

A minor phase of the field testing program consisted of placing three aluminum cables with various types of soldered joints in the fender well of a car so that the soldered joints would be continuously exposed to road splash. Three cables were connected in series between the battery and the starter motor so that the starter motor current flowed through the exposed joints. The test was conducted for over a year and the total mileage was over 10,000 miles. No failures occurred, and the resistance increase of each joint was small.



Borides *Abrasion resistance leads to their use for such parts as cylindrical die liners, while corrosion resistance makes these materials attractive for spray nozzles.*



Aluminides *Their high strength and good impact resistance at elevated temperatures have led to their evaluation for turbine vanes and other parts designed for high temperature service.*

New Refractory Hard Metals

Possess characteristics between those of metals and ceramics . . . Have excellent high temperature properties, and corrosion and wear resistance.

by **JOHN L. EVERHART, Associate Editor, Materials & Methods**

● BORIDES OF the transition metals and nickel aluminides form a group of new high-temperature materials having both metallic and ceramic characteristics. These materials have been referred to as "refractory hard metals" but there is also some tendency to call them "cermets." This designation seems appropriate if the word "cermet" is considered in the broad sense, implying a material having characteristics intermediate between those of a metal and a ceramic.

Although the commercial borides are made by powder metallurgy processes similar to those used in producing the cemented carbides, there is a distinct difference in the product obtained after completing the sintering operation. In general, the borides react with metallic binders at elevated temperatures and ternary or quaternary compound formation occurs. Experience with cemented carbides, therefore, does not provide a direct basis for comparison in evaluating the boride-base products.

The transition metal borides are compounds with some metallic properties. They can be polished to a high luster and their electrical and thermal conductivities are within the range of pure metals. Further, their temperature coefficients of resistivity at room temperature are positive, one of the criteria often used to define a metal. The high melting points (up to 5000 F) and refractoriness of these materials combined with their other properties give some justification for calling them "refractory hard metals." However, recent work has shown that at sufficiently high temperatures the slope of the electrical

Properties of Borides and Aluminides

Type	Zirconium Boride	Chromium Boride		Molybdenum Boride	Nickel Aluminide
		300 series	400 series		
Essential Constituents	Zr, B	Cr, B	Cr, B	Mo, B, Ni	Ni, Al
Physical Properties					
Density, Lb/Cu In.	0.180–0.191	0.223–0.225	0.225–0.263	0.299–0.310	0.205–0.210
Melting Range, F	5400	3200–3450	3400–3600	2550–2650	3000–3050
Coef of Exp per F:	3.2×10^{-6}(a)	5.45×10^{-6}(b)	5.5×10^{-6}(b)	—	8.0×10^{-6}(b)
Elect Res, Microhm-Cm 30 F:	17	38–78	27–54	66–71	12–30
Thermal Shock Resistance	Very good to excellent	Excellent	Excellent	—(c)	—
Oxidation Resistance—Air (Weight gain in 100 hr) mg/sq cm	6(d)	2.5–3.0(d)	5.0–13.0(e)	—	1.0–3.0(e)
Mechanical Properties					
Transverse rupture strength, psi	63,000(d)	80,000–138,000(d)	90,000–140,000(d)	to 100,000(f)	60,000–150,000(e)
Stress-to-rupture strength, psi at 1800 F	18,500 (100 hr)	12,000–28,000 (100 hr)	14,000 (over 1000 hr)	—	to 12,000 (100 hr)
Rockwell Hardness	R_A 88–90	R_A 73–86	R_A 77–88	R_A 88–90	R_A to 75

NOTES:
(a) 70–2200 F.
(b) 70–1800 F.
(c) Not intended for high temperature service.
(d) At 1800 F.
(e) At 2000 F.
(f) At 70 F.

resistivity curve deviates from that typical of a metal, thus indicating that these compounds may not be truly metallic. The actual status of the borides thus remains to be determined.

Regardless of what these borides are finally called, a number are now available commercially. These offer the materials engineer another group of materials whose special properties may assist in solving some of his more difficult problems. For purposes of discussion, these new materials can be divided into four groups: zirconium borides, chromium borides, molybdenum borides, and nickel aluminides.

Zirconium Boride

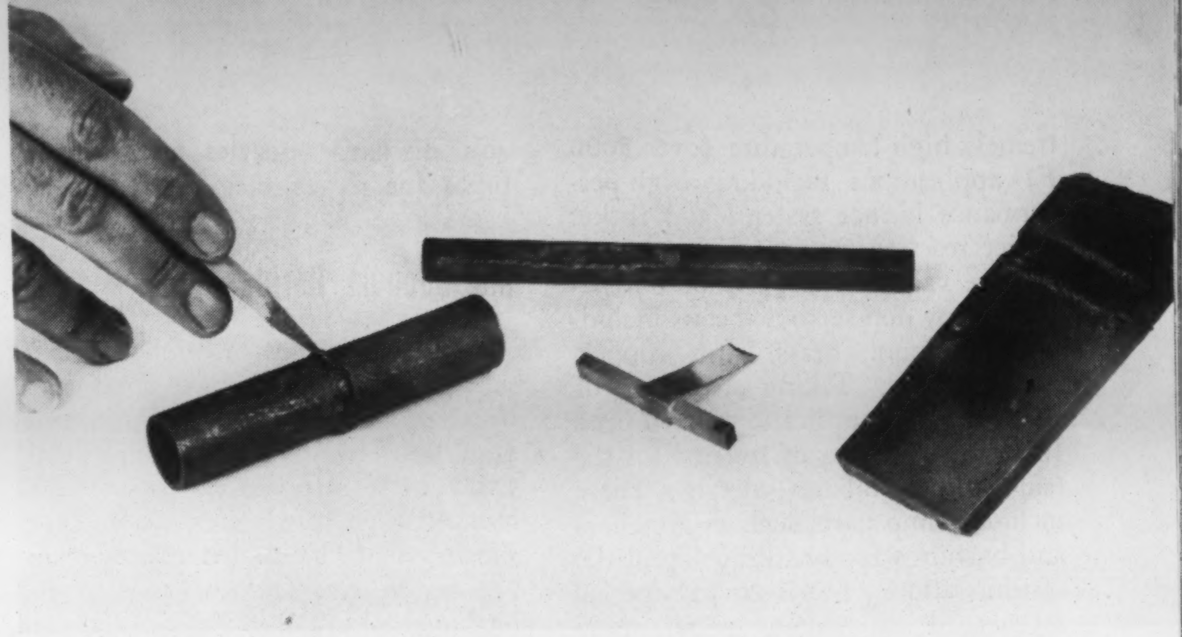
This material, originally made by pressing and sintering or hot-pressing the pure boride, has been improved greatly by incorporating a binder phase. The sintered product is a mixture of the borides of zirconium and a binder.

Zirconium boride has a high melting point and good high temperature mechanical properties, although it is not so resistant to oxidation in air at high temperatures as some of the other borides. The material is hard, but brittle in comparison with metals, particularly at room temperature. At elevated temperatures, the brittleness is considerably reduced.

The corrosion resistance of zirconium boride is one of its outstanding properties, and one which should lead to many applications. The material shows excellent resistance to nitric acid, hydrochloric acid, and to a number of molten materials including aluminum, copper, tin, magnesium, and the fluorides. Resistance to attack by hydrogen peroxide and to molten silicon and brass is good. Molten iron and molten Inconel attack the boride at rates which indicate that zirconium boride is not a suitable material for handling these metals in the liquid state for extended periods of time.

Bonded zirconium boride is fabricated by hot pressing or by cold pressing and sintering, with densities of the order of 95% of theoretical being obtained. Grinding with diamond wheels is required to obtain final dimensions.

Zirconium boride has found a number of applications in the short time it has been available commercially. Its high melting point makes it attractive for service in ex-



Molybdenum parts joined by brazing with a molybdenum-boron compound include butt joints in tubing and plate, thin sheet joined to bar, and tubing produced from skelp.

The wear resistance of the borides is applied advantageously in die or mold liners and plungers for automatic presses used in the production of small parts from highly abrasive materials.

tremely high temperature (over 5000 F) applications including high-performance burner systems and rocket or jet reaction systems. This boride has the valuable property of not being wet by non-ferrous metals including aluminum, brass, zinc, copper, lead, and tin. Taking advantage of this property, applications have been found in a number of systems for the handling of molten metals. These include pump parts such as impellers and bushings for handling liquid die casting alloys, bearings to operate submerged in molten metal, spray nozzles for the production of metal powders by atomization, and thermocouple protection tubes.

Because of high hardness and good electrical properties, future applications of this material may include electrical contacts. Its excellent resistance to wear will lead to other applications.

Chromium Boride

There are two series of bonded chromium borides in commercial production. One series is characterized by oxidation resistance at elevated temperatures which is superior to that of zirconium boride and many of the cermets. This group, called the 300 series, has good high-temperature strength and hardness and is less brittle than zirconium boride. To improve the resistance to impact, the 400 series was developed. This group of chromium borides has greatly superior stress-to-rupture properties and improved impact properties over the 300 series.

Some corrosion results have been reported for chromium boride. Dilute nitric acid does not attack the material and it shows excellent resistance to concentrated nitric, hydrochloric, sulfuric, and hydrofluoric acids. Perchloric acid attacks chromium boride slowly, while the compound is rapidly dissolved by fused sodium peroxide and nitrate-carbonate mixtures.

Applications are based on the corrosion and abrasion resistance particuarly. They include rubbing seals and bearings for elevated temperature service and hard-facing on a mild steel base for wear and corrosion resistance in the chemical industry. Bonded chromium boride has also been suggested for steam and gas turbine blades, valve inserts and seats for internal combustion engines, and discharge nozzles and exhaust tubes for jet engines.

Molybdenum Borides

Like the borides mentioned previously, these materials have good electrical properties, high hardness, and good wear resistance. Although relatively little information is available on corrosion properties, tests have shown that a molybdenum-nickel boride has excellent resistance to dilute sulfuric acid.

As a cutting tool material, one molybdenum nickel boride shows considerable promise. It is not as hard as some grades of tungsten carbide and cannot be evaluated by the same type of test because of different friction characteristics of the material. Actual cutting characteristics are being evaluated by machine test. Indications have been obtained that for cutting aluminum and brass this material compares favorably with high-speed steels and cemented carbide tool materials. Additional work is required to determine the proper conditions for use on other conventional materials. With all of its constituents available in North America, this molybdenum nickel boride is probably the best substitute for carbides in case of an emergency.

Like the chromium borides, some future applications of the molybdenum nickel borides will undoubtedly be based on their corrosion and abrasion resistance. Among the more promising possibilities along these lines are centrifuge nozzle shapes and acid spray nozzle inserts. The wear resistance is used to advantage in die or mold liners and plungers for automatic presses used in the production of small parts from highly abrasive materials.

A different application of this material is a brazing operation in which Mo-Braze, a molybdenum-boron base composition is employed for joining molybdenum, tungsten, tantalum and columbium. For this purpose it is obtainable either as powder to be used for furnace brazing or as rod for use with shielded arc welding equipment. The brazing compound has a lower melting temperature than molybdenum, which is advantageous in brazing.

In welding molybdenum, using molybdenum wire, the temperature required is high enough to create a broad embrittled zone around the joint. With the new compound the temperature required is lower and the embrittled zone is greatly reduced. Thus it is possible to braze thinner sheet successfully with Mo-Braze, and successful joints have been made with sheet as thin as 0.020 in. While the brazing is done at a relatively low temperature, the resulting joint has the property of being useful at operating temperatures above the brazing temperature.

The molybdenum-boron base composition is used particularly for brazing electronic components in vacuum tubes and magnetrons. The compound has the advantage that it does not poison vacuums of the order of 10^{-6} microns. It can also be used to join other metals for high-temperature electronic or other service.

Nickel Aluminide

Latest materials to be produced on a commercial scale in the hard metal category are nickel aluminide products. These are materials composed largely of intermetallic nickel-aluminum compounds. Several grades are available.

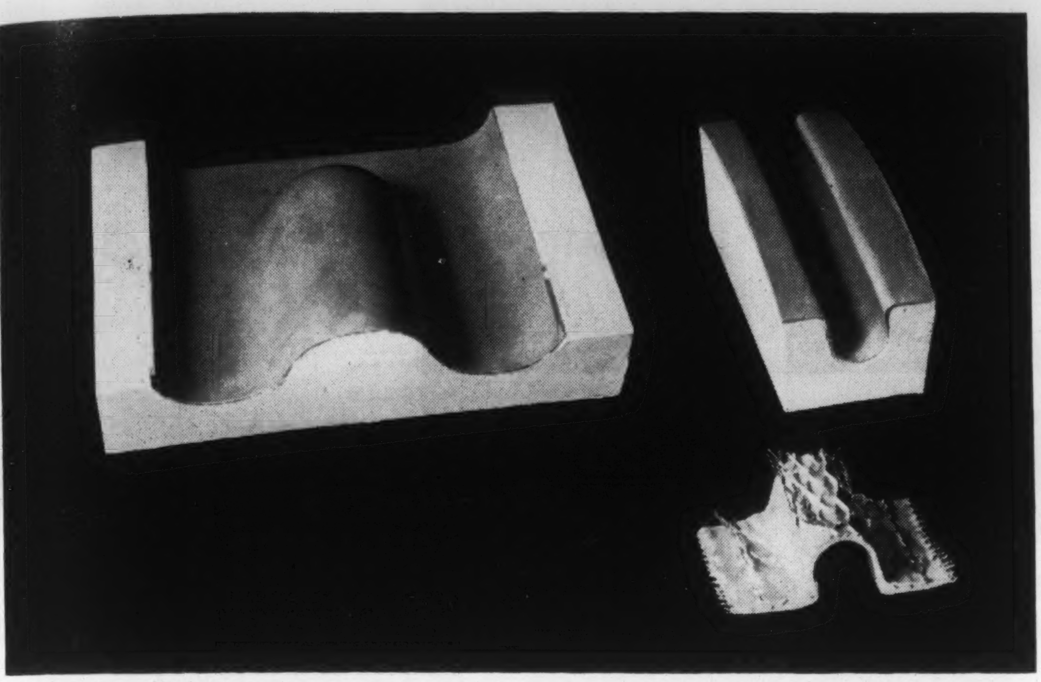
The melting points of the aluminides are higher than those of either of the metals from which they are formed. Electrical resistivity is in the same range as the borides mentioned previously. However, the commercial material has high elevated temperature stress to-rupture properties combined with better ductility than is usually found in cermets. The impact resistance of nickel aluminide is very promising, being better than 15 in.-lb. in the NACA drop test over the entire range from room temperature to 2100 F. Its heat shock resistance and strength at 2000 F are also excellent.

These properties, combined with the fact that the product contains no strategic materials, have led to its consideration as a logical replacement material for high-temperature service. It appears to be particularly suited for applications requiring high strength and good impact resistance at elevated temperatures. At present nickel aluminide is being evaluated for stator blades or guide vanes in jet engines.

Acknowledgement

The author acknowledges the assistance of the personnel of the Borolite Corp., a consolidated subsidiary of The Carborundum Co. in preparing this article.

Why Epoxy Resins for Laminated Tooling?



These tools are made with laminated epoxy facing, backed with a melamine casting compound. The piece at lower right shows the construction of the facing laminate before casting the backing material.

Their low shrinkage and good adhesion are solving many of the problems inherent in production and use of plastic tools in metal working industries.

by JOHN DELMONTE,

Consulting Engineer, Furane Plastics, Inc.

● EPOXY RESINS, one of the most recent additions to the field of plastics materials, have rapidly taken their place in the plastics tooling picture. In many tooling applications for the aircraft and automotive industries, epoxy resins have superseded other types of bonding media in glass fiber laminated structures. The two most important reasons for this change are the low shrinkage of epoxy resins and their outstanding adhesion to glass fibers.

Volumetrically, the unfilled resin may shrink about 0.5% on curing, though this is reduced still further when glass cloth reinforcing is added. This low shrinkage lends to the material high dimensional stability, which is perhaps the design feature most attractive to tooling engineers. First, it increases the accuracy of reproduction of the contours of the pattern mold, and second, it maintains this accuracy to a higher degree when the tool is subjected to service stresses and handling.

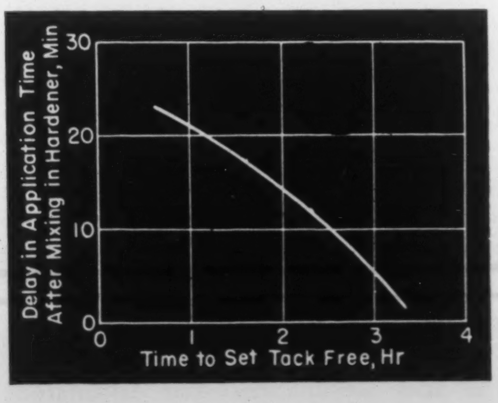
The adhesion of epoxy resins to glass, metals and ceramics has been recognized for some time, and numerous general purpose adhesives have been developed to make use of this property. In laminated plastics tooling, this results in high interlaminar bond strengths and longer life for the tool. Actual interlaminar bond strengths may be determined by edge-wise compressive strength tests, where strengths in the range of 50,000 to 60,000 psi will be encountered. In wear tests perpendicular to the planes of laminations, epoxy tooling laminates will display a life expectancy many times that of some of their competitors. This feature is particularly useful, for example, in router jigs where high bearing pressures are brought to bear against machined edges of the laminates. This high adhesion is also important where metal stiffeners or inserts are needed in the tool. These may be used for localized reinforcement or for other purposes such as drill jigs, where steel bushings are placed in the plastic tool to locate the holes to be drilled.

Besides these specific properties which set the epoxies apart, they have the other advantages of reinforced plastics structures. They are light in weight, durable and strong. A major part of the question of whether to use epoxies must be answered by balancing the particular requirements of each job against the increased cost of the material.

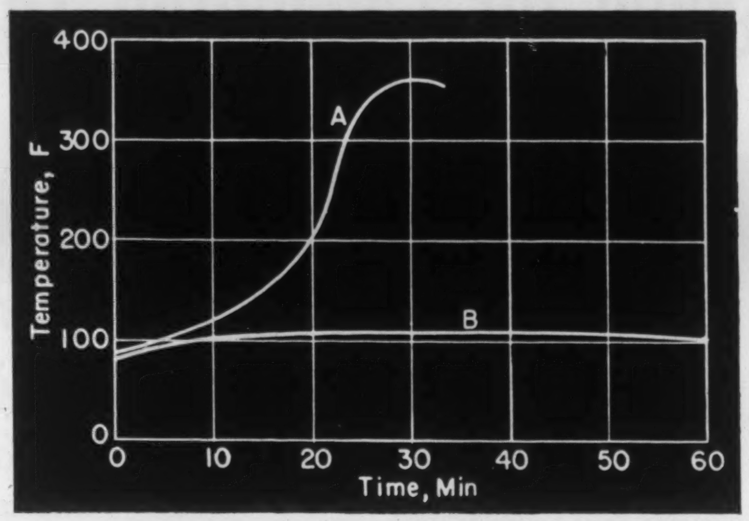
How To Select and Use Epoxy Resins

When reviewing the requirements for laminated tooling, the engineer must consider the many types of epoxy resins available for this purpose. There are liquid resins of varying viscosity, solid resins which may be melted or dissolved, and hardeners which are effective at room temperature or elevated temperatures. Because the laminating resins for tooling purposes are usually prepared against plaster mock-ups which may cover many square feet in area, room temperature setting qualities are usually necessary and the materials should contain no volatiles that may contribute to dimensional instability.

Opinions differ as to the desired range of viscosity of the material.



Note how a delay of a few minutes before application can materially reduce the set time for an epoxy laminate (Epocast II + 10% hardener).



Pot Life and Exothermic Qualities of Epoxies

In the absence of its hardener, an epoxy resin possesses good stability and storage life. To prepare it for use, it must be combined with its hardener, which generally takes part in cross-linking of the molecules by chemically bonding at the epoxy terminal groups. Room temperature setting hardeners usually employed for epoxy resins are poly-amines. Once the hardener has been dispersed into the epoxy resin the combination is activated and ready for use.

The useful pot life of a resin is measured from the time of activation by the hardener until the mixture becomes too thick to be useable. This length of time is determined by the amount of resin and hardener, the concentration of hardener, and the ambient temperature.

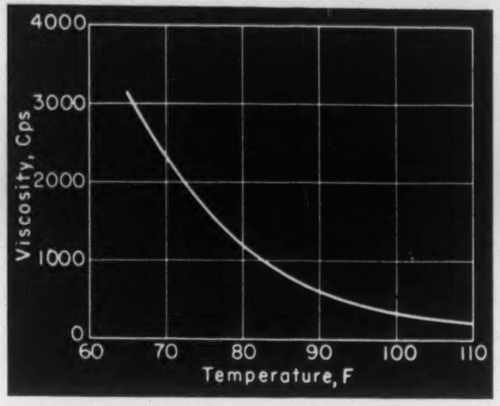
Once the resin begins to warm exothermically, the pot life is nearly over. The upper curve on the accompanying graph indicates the exothermic temperature rise for a 100 gm mass of a typical epoxy resin and hardener mixture. Temperatures of 350 to 400 F are not uncommon for an unfilled epoxy resin. The results shown were obtained with resin specimens cast in a paper cup with a thermocouple positioned at the center of the mass. The lower curve on the graph shows the effect of ten layers of glass cloth reinforcement on the exothermic temperature rise of the same resin and hardener concentration as shown in the upper curve. As well as the fillers or reinforcing fabrics present, the amount and shape of the mass of resin will also influence the actual temperature rise. For example, if the resin were spread over a large area the temperature rise would be much less than it would be for the same amount of resin mixture in a solid mass.

The concensus seems to favor the moderate viscosity range of 2000 to 4000 cps, though some organizations prefer the thicker, higher viscosity range of 20,000 to 40,000 cps. It should also be borne in mind that the viscosity of epoxy resins, as characteristic of liquid polymers, shows a marked dependence upon temperature. This dependence is such that the viscosity may fall well below 500 cps as room temperature increases. Life and storage qualities of the better grades of epoxy resin are good and the materials do not require refrigeration.

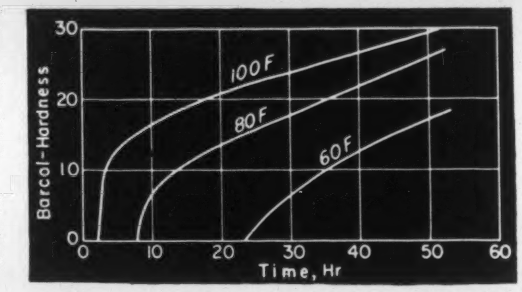
Ease of Wetting—The impregnator and lay-up man for laminated tooling look for good wetting of the glass fiber reinforcement. The term "wetting" is a qualitative expression indicative of the ease with which the resin strikes through the glass fibers. The open mesh glass fabric used for laminated tooling makes it relatively simple for the medium viscosity resins to penetrate, wet, and force bubbles to the outside surface. This feature may be observed most readily when a transparent, unfilled epoxy resin is used.

Controlling Run-Off on Vertical Surfaces — A requirement diametrically opposed to the wetting property, is the ability of the resin to remain in place on vertical surfaces of tooling during the lay-up process. A medium viscosity, relatively fluid resin that penetrates and wets glass fabric easily will tend to run down to horizontal surfaces and leave starved, resin-thin areas.

A solution that may be more satisfactory than specifying a more viscous resin for the job, is to allow the resin and its hardener to remain in the mixing container for a period of time 5 or 10 min shorter than its useful pot life before applying it to the vertical surface. The longer it remains in the container, the quicker it will set after application. This is due to the exothermic reaction which generates heat as the mass of resin and hardener approaches its set. The coating developed in this manner is, in effect, the gel or first coating frequently employed by laminators of epoxy tooling. The actual time the resin and its hardener should be left in the container before application depends to a great extent on the amount of resin being mixed, the surface area to be covered, ambient temperature conditions, and the concentration



Typical viscosity characteristics of an epoxy resin (Epocast II).



Hardness of epoxy laminate as influenced by ambient temperature.

and nature of the hardener.

Pot Life and Cure

In general, the useful pot life of a room temperature curing epoxy resin and hardener is in the range of 20 to 45 min. Other hardeners and epoxy resins may have a useful pot life of several days; but for these, curing temperatures of 150 to 250 F are required. If extension of the pot life is necessary, refrigeration will lengthen it considerably, but this added advantage must be balanced against the inconvenience and expense which refrigeration incurs.

Unlike the techniques for preparing plastics parts where high strength, tightly woven fibers, pressure and temperature are involved, laminated tooling uses contact pressure, wide open mesh fabrics and room temperatures. This leaves the curing characteristics dependent on the amount of hardener used, the thickness of the laminated tool and the ambient temperature of the work room. As was mentioned before, the ambient temperature has a substantial effect on the rate of cure. Although the ultimate strength of laminates curing at various temperatures will be the same, the rate of attaining this strength at 60 F is much slower than at 80 or 100 F. Wherever possible, warm air from a space heater will do much to accelerate the cure of the epoxy resin.

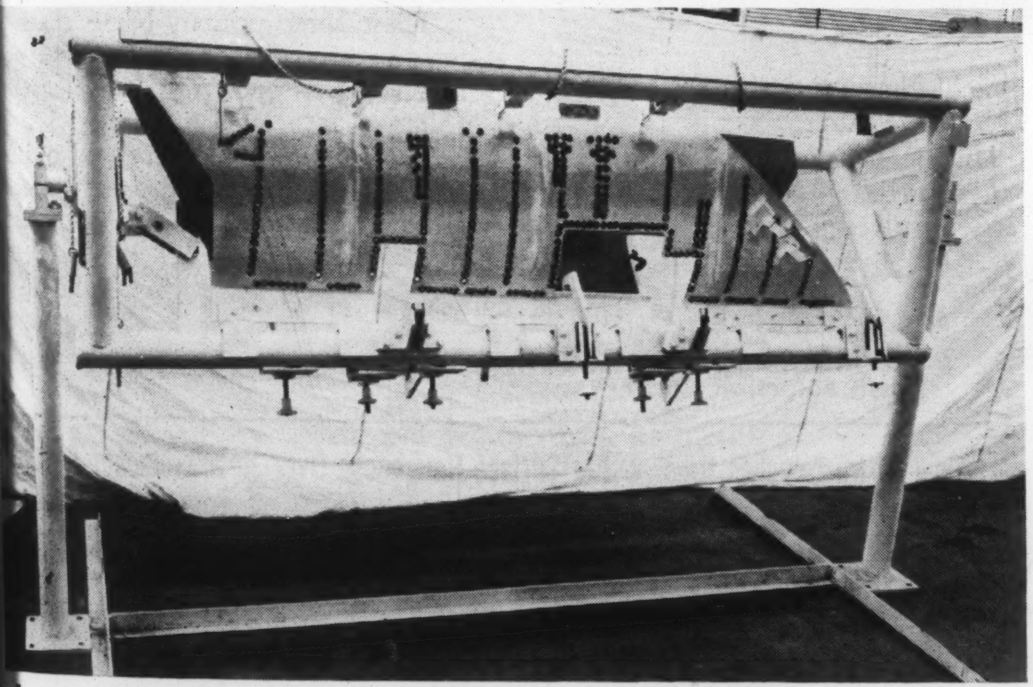
Epoxy resins, because of their remarkable adhesion, require particular care and attention in releasing the finished tool from the mold or form. If plaster forms are to be used, a well-sealed plaster surface and several wax coatings are reported to be satisfactory. The manufacturers of epoxy resins for laminating purposes will recommend suitable release agents for their materials.

Other Considerations

Laminated epoxy resins have been extended into the field of draw dies and some drop hammer dies, since they seem to display the wear and durability essential to these operations. Furthermore, their life expectancy and usefulness for some operations are better than those available with other forms of plastics tooling. Where for economy purposes, it may be necessary to employ lower cost materials, polyesters, phenolics, Calcerite-A (a filled melamine casting compound) and others have been used for back-up purposes behind the working face of epoxy laminating resin.

Though the epoxies have a high degree of dimensional stability, when large contoured sections are to be reproduced, localized stiffening ribs should be included in the tool design. The stiffening ribs may be of metal or plastics tubing, or of honeycomb cores if lightness in weight is desired. The epoxy resin itself will secure the reinforcing member firmly to the over-all structure.

The major limitation in the use of room temperature curing epoxy resins is that the highest heat distortion point of these resins to date is around 180 to 200 F. The physical properties of the materials fall off rapidly above this. Also if careful control is not exercised during the addition of the hardener and during the lay-up of the resin and glass fibers, the qualities of the laminate will be inadequate for tooling purposes.



Epoxy laminated assembly and drill jig produced at Douglas Aircraft Co.

Typical Physical Properties of an Epoxy Tooling Laminate* at 70 to 75° F.

(Contact Pressure and Room Temperature Cure)

Resin Content	48 to 50%
Reinforcement	#1500 glass fabric or equivalent
Density	1.6g/cc
Flexural Strength	37,000 psi
Flexural Modulus of Elasticity	2.1 x 10^6 psi
Tensile Strength	31,000 psi
Water Absorption—24 hr	<0.2%
Flexural Strength after 24 hr immersion in water	35,000 psi

**Epocast 4B2 Laminating Resin*

Selecting a Brush Finish

Power brushing can handle many different metal finishing jobs, but good results require the right brush for each job. Here is a guide to proper selection of brushes and brushing conditions.

by R. O. PETERSON
Manager, Technical Dept., Osborn Mfg. Co.

● A number of useful finishes, both preliminary and final, can be produced by brushing, and many brush finishing applications cannot be handled satisfactorily in any other way.

The importance of brush finishing lies primarily in the flexibility of the brush surface as contrasted with the hard surface of grinding and polishing wheels. The flexibility allows the brush to conform to slight irregularities and, therefore, act uniformly over the entire surface. Such flexibility reduces the danger of tracking or scratching by "wild grains" in polishing and seems to reduce the occurrence of "drag lines" in buffing. It also results in the blending of sharp edges without the creation of new edges; by eliminating areas of stress concentration, brushing often contributes to the fatigue life of a metal part. Brush flexibility also means that working pressure can be varied within fairly broad limits and that a machine which has become too inaccurate for precision grinding may still be suitable for brushing. Since brushing does not remove large amounts of metal, it is often more suitable than other methods where close tolerances must be observed.

Brush Characteristics

In the selection of a brush finish, three primary brush characteristics are involved: flexibility, finishing ability and speed of action. The flexibility of a brush determines the extent to which it can contact low spots or narrow recesses on a surface and the extent to which it has a lifting or shearing action on surface contaminations or projections. The finishing ability of a brush determines how fine a surface can be produced. The speed of action of a brush determines the rate at which contaminations are removed and projections are cut down.

These three primary brush characteristics are affected by the type of brush and its operating conditions as follows:

Type of Fill—The fill or brush material may be metallic or non-metallic. Most metallic fills are steel

Brush Selection Chart

	For Surface Roughness Below 30 Microinches Rms.			For Surface Roughness Over 30 Microinches Rms.*		
FLEXIBILITY	Medium — High			Low — High		
FINISHING ABILITY	Very Fine — Medium			Fine — Coarse		
SPEED OF ACTION	Medium — Very Fast			Medium — Fast — Medium Fast		
	Cord and Fabric	Tampico and Treated Fiber	Fine Wire with Compound	Wire Wheel	Wire Section	Coiled Knot
MAJOR APPLICATIONS (in order of general usage)	Cut and color buffing Surface blending Light scale removal Rounding edges Burr removal	Small burr removal Rounding edges Light scale removal Surface blending Cleaning Satin finishing	Medium burr removal Light scale removal Satin finishing Rounding edges	Heavy burr removal Rounding edges Rust and oxide removal Scale removal Cleaning Surface blending	Cleaning Medium scale removal Rust and oxide removal Satin finishing Surface blending Burr removal	Heavy scale removal Rust and oxide removal Satin finishing Rounding edges Burr removal (from very hard metals)

** For very ductile metals see also Brush Adjustment Chart on facing page.*

This brushing set-up deburrs 1400 brass parts per hour.

wire, although stainless steel is sometimes used. Cord, fabric, Tampico fiber, various treated fibers and nylon fiber are common non-metallic fills. The fills may be used with or without abrasive compound. In general, metallic fills have less flexibility, less ability to produce fineness of finish, and greater speed of action than non-metallic fills. Cord and fabric brushes, as commonly used, have less flexibility, greater ability to produce fineness of finish, and generally, but not always, less speed of action than fiber brushes.

Size of fill—As defined here, size of fill refers to the diameter of wires or fibers used and to the size of abrasive particles where compound is used in the fill. Wire diameter ordinarily ranges from 0.005 to 0.050 in. Size of fill affects primarily finishing ability. The smaller the size of fill, the greater the finishing ability. However, it has been found that higher surface speeds with fine wires produce surfaces similar to those produced by larger wires at slower speeds.

Trim Length—Trim length is the length of the fill material that extends beyond the face plates or the back of the brush. Trim length affects primarily flexibility. The greater the trim length, the more flexible the brush; conversely, the smaller the trim length, the tougher the brush.

Face Density—Face density is the density of fill material at the face of the brush. The face density of a wheel or cylindrical brush with wire or fiber fill may be raised by increasing the inside diameter with respect to the outside diameter, thus increasing the number of wires or fibers that form a face of given size. In general, a greater face density means less flexibility, greater finishing ability and greater speed of action.

Surface Speed—Normal brush speeds are 5500 to 9000 surface ft per min for metallic fills and 4000 to 7500 surface ft per min for non-metallic fills. An increase in surface speed increases the centrifugal force on the fill and thereby hardens the brush face. The result is less flexibility, greater finishing ability and greater speed of action.

Other factors must sometimes be

Brush Adjustment Chart

If brush works too slowly . . .	If brush works too fast . . .	If burrs are peened instead of removed . . .	If finish is too coarse . . .	If finish is too fine . . .	If brushing action is not uniform enough . . .
1. Increase surface speed by increasing wheel dia or rpm 2. Decrease trim length and increase fill density 3. Increase filament dia	1. Reduce surface speed by reducing wheel dia or rpm 2. Reduce filament dia 3. Reduce fill density 4. Increase trim length	1. Decrease trim length and increase fill density 2. Change to non-metallic brush such as treated Tampico with burring compound	1. Decrease trim length and increase fill density 2. Decrease filament dia 3. Change to nonmetallic brush with suitable compound at recommended speed 4. Use auxiliary buffing compound	1. Increase trim length 2. Reduce brush fill density 3. Reduce surface speed 4. Increase filament dia	1. Increase trim length and decrease fill density 2. Devise manual or mechanical fixture to avoid irregular offhand manipulation

considered. Among these are the quality of the fill material, the overall diameter of the brush, and special fill treatments such as a crimp in wire or nylon fiber.

Types of Brushes

The relatively large number of brushing variables makes available a great many different combinations of flexibility, finishing ability and speed of action. However, six general types of brushes are sufficient to handle the majority of finishing applications.

Cord or Fabric Brush—Fast-cutting, medium-flexible brush wheel used with cut and color compounds to produce surfaces with roughness of the order of less than 10 microinch rms.

Tampico and Treated Fiber Brush—Flexible, fast-cutting brush wheel used with burring compounds of tacky composition to produce surfaces with roughness of about 8 to 10 microinches rms.

Fine Wire Brush with Compound—Wire brush of medium or high fill density and small fill size (0.008-in. dia or finer wire) with burring compound.

Wire Brush Wheel—A good general-purpose wire brush of wide face and high fill density for fast cutting and surfaces with roughness as low as 30 microinches rms.

Wire Brush Section—A medium-flexible wire brush of narrow face and medium density especially suitable for contoured surfaces.

Coiled Knot Brush—A narrow-face, low-density tufted wire brush used where great flexibility and impact action are needed, as in the removal of welding fluxes.

The first three types of brushes are generally restricted to applications where a surface having roughness less than 30 microinches rms is needed. The last three types of brushes are generally restricted to applications where the maximum allowable surface roughness exceeds 30 microinches rms. The relations among the different types of brushes are shown in the Brush Selection Chart, and the major applications of each type are listed.

Brushes used for metal finishing may be either helical and sectional in construction. A sectional brush is built up by clamping together individual narrow-face sections to the face width desired. Usual face width range is 1/2 to 6 in. Wider brushes are generally of helical construction.

Factors Influencing Selection

It is not uncommon to use one brush for several different types of work where manufacturing is on a job-lot basis. On a high-production basis, however, efficiency demands brushes and brushing conditions selected especially for specific jobs. For each case, the following factors must be considered:

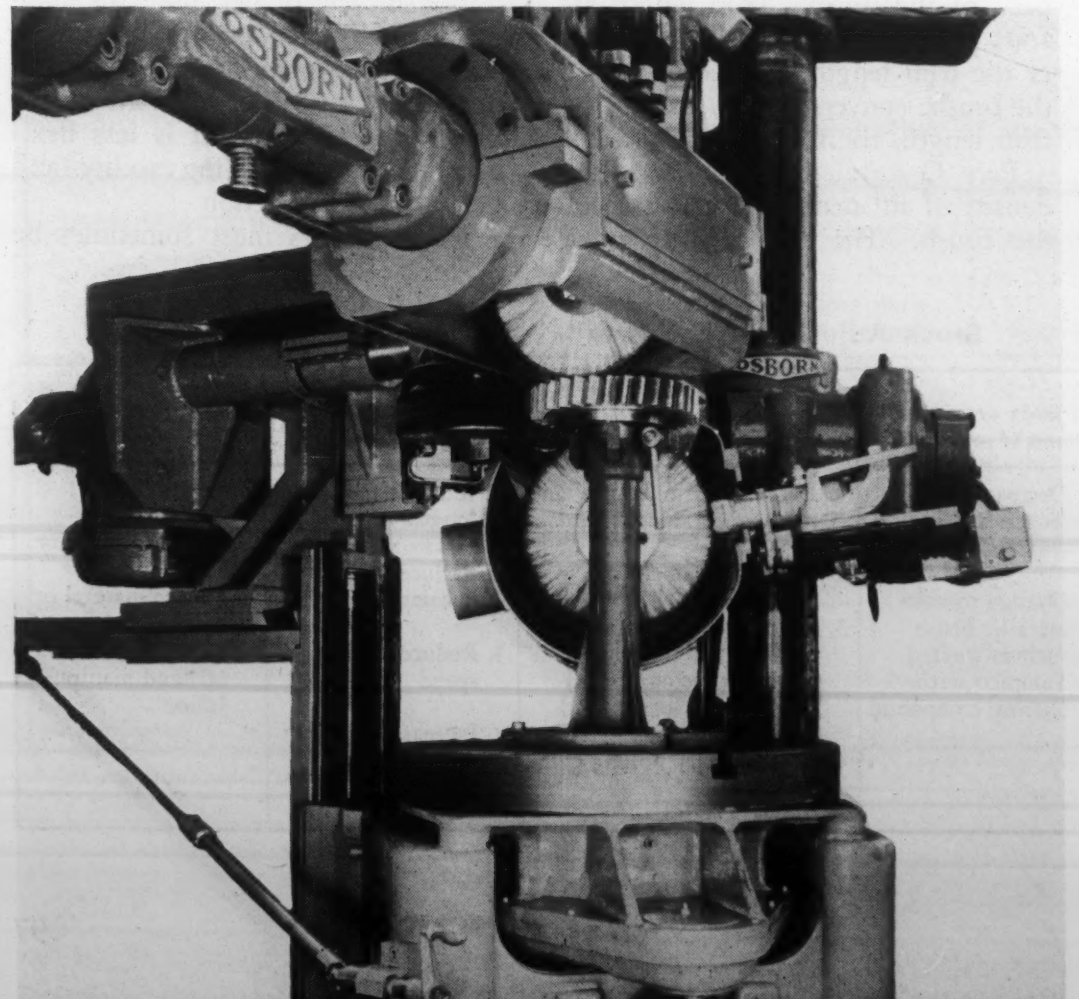
Nature of Work—The metal finishing applications of power brushing can generally be classified as cleaning, burr removal, blending, oxide removal, forming radii and satin finishing. In any specific case, brush selection depends on the exact surface conditions encountered. This is particularly true of cleaning and the removal of oxides and burrs, since surface encrustations and projections may range from light to heavy. The types of brushes suitable for these various operations are indicated in the Brush Selection Chart.

Surface Finish Required—Surfaces having a roughness of below 10 microinches rms can be obtained by brushing. On the Brush Selection Chart, fineness of finish increases from right to left. As the Chart indicates, brushes commonly used for finishing can be divided into two groups: those suitable for finishes finer than 30 microinches rms and those suitable for coarser finishes. Although it is obvious that the brush and brushing conditions selected must be capable of producing the specified finish, it is also important that the finish not be too much better than necessary, for even a slight improvement in surface finish often costs money.

Type of Metal and Its Condition—All common metals are adapted to brushing, but proper brush selection depends on the hardness and electrolytic corrosion characteristics of the metal. Only fiber brushes are used for a relatively soft metal such as zinc. For metals such as stainless steel, aluminum and magnesium, fiber brushes may be used alone or after wire brushing to prevent electrolytic corrosion resulting from embedded particles. Alternatively, a stainless steel wire brush may be used on stainless, and embedded particles may be removed from light metals by other cleaning processes. Brushing equipment used for magnesium must include a dust collecting system to avoid explosions. Careful brush selection is necessary for heavy brushing of ductile metals to avoid mere peening down of burrs.

Size and Clearance Limitations—No one size or shape of brush could adequately reach all surfaces of a complex part. A brush that is most suitable for each different type of surface must be selected. A great variety of standard shapes and sizes is available, although, if production volume warrants, brushes may be designed especially for a specific application. For example, specially designed cylindrical brushes may be used for tubing and cored holes, and

Three brushing heads are set up here to deburr a large jet engine gear. Top and bottom surfaces are finished by treated Tampico brushes and the profile by a fine wire brush.



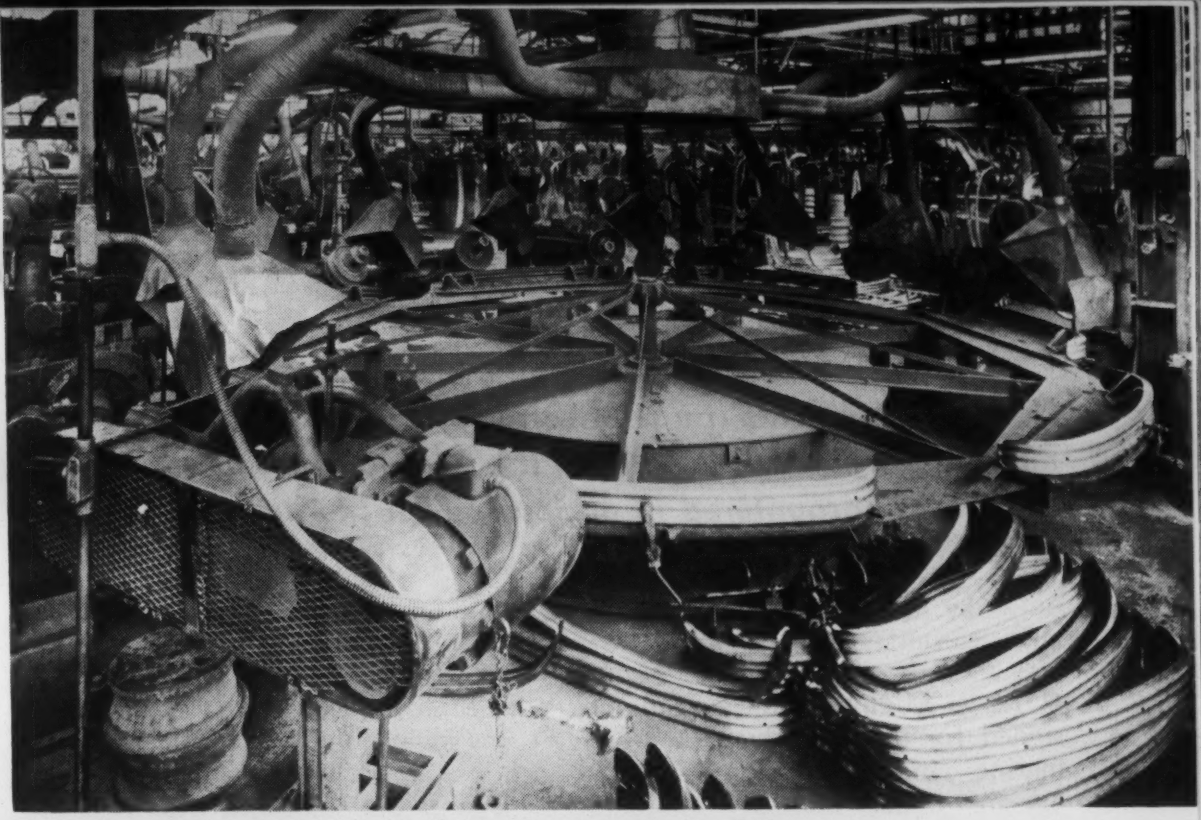
specially designed end brushes may be used for recesses and blind holes. Brushes with small diameter or high flexibility are needed for fillets. Brushes with varying degrees of flexibility are needed to reach the roots of threads, to finish thin, unsupported sections, and to penetrate small crevices and perforations. Where sharp edges and corners are to be maintained, control of rotation and/or masking may be needed.

Equipment Needed or Available—The brushes and brushing conditions needed, the size, shape and possible positions of the part, and the production volume determine the type of equipment needed. In general any brush drive with arbor or spindle size sufficient to avoid excessive deflection or vibration and power sufficient to avoid excessive slowdown under load is adequate. For minor off-hand applications, a brushing lathe of proper power and speed is suitable and often readily available. For more complex jobs or long production runs, some type of standard automatic brushing machine may be justified. For special jobs, where comparative costs indicate its feasibility, a special brushing machine designed for the application may be justified. Sometimes portable or flexible shaft equipment is needed.

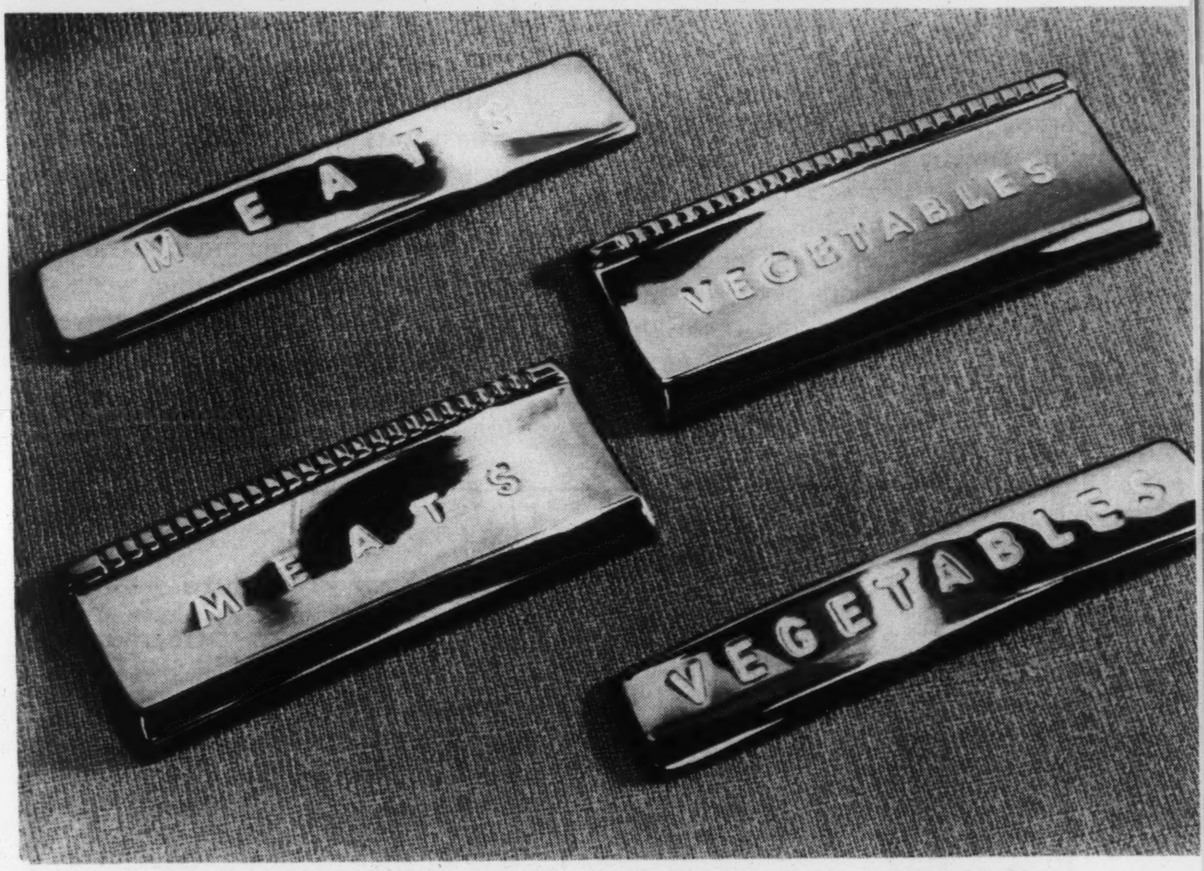
Production Rate—Production volume affects primarily the type of brush drive selected, but production rate is a factor that enters into the selection of the brush and the brushing conditions. As the chart indicates, fast cutting action is not necessarily compatible with a fine finish. Where a fine finish is not important, the production rate may establish the type of finish achieved. Where a fine finish is important, the production rate will more likely determine the number of brushing machines needed.

Special Technical Requirements—Sometimes a special technical requirement may override other factors in importance. An example of such a requirement is the rounding of a corner to remove about 0.015 in. of metal.

When all of the factors discussed above have been properly evaluated, it is possible to select approximately the proper brush and brushing conditions without tedious and expensive trials. If the brush selected fails to perform exactly as desired, adjustments must be made. The usual short-comings that need attention and the suggested adjustments for each are listed in the Brush Adjustment Chart.

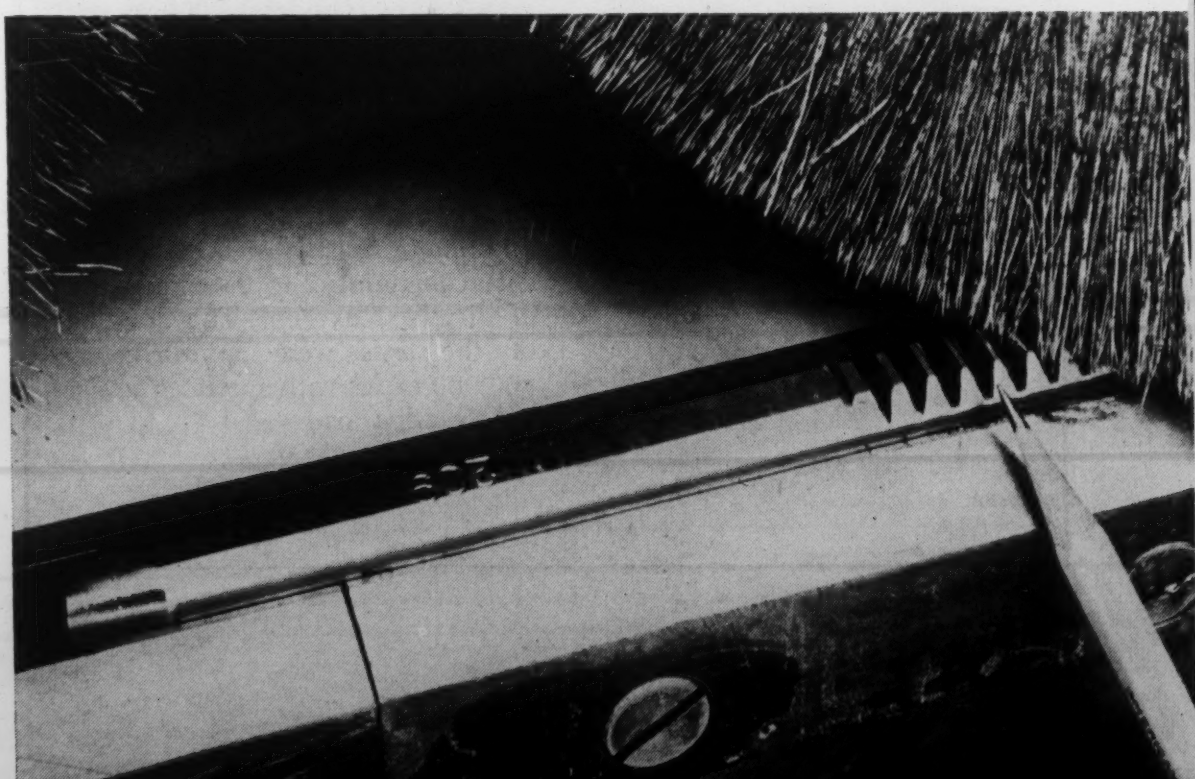


This high-production brushing set-up finishes bumpers prior to plating.



These stainless steel parts are mass finished with three brushing heads in one pass. Brushing has less tendency to produce "drag lines" than conventional polishing and buffing.

The flexibility of a brush is used to great advantage in the deburring of this gear rack which is 17 ft long and contains more than 1000 teeth.



Wear and Corrosion of Materials

Here is how a wide range of corrosion resistant materials will stand up under the unusual bearing conditions encountered in nuclear power plants.

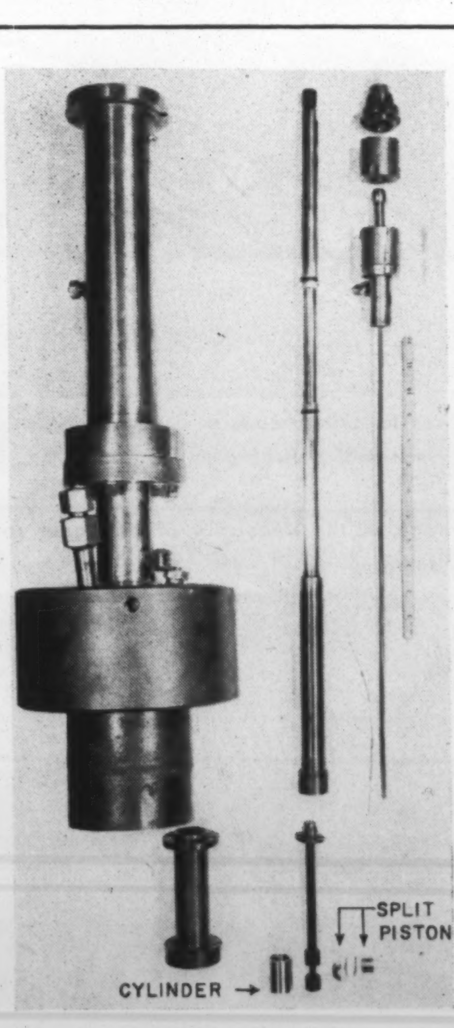
by **R. C. WESTPHAL** and **J. GLATTER**, **Westinghouse Electric Corp.**

● IN A NUCLEAR power plant designed for the propulsion of a submarine, many mechanical devices operate under unusual conditions. These devices, such as antifriction bearings, linear sliding guide bearings and even nuts and bolts must function in high-temperature high-purity water. Since there is no lubricant present but the water, the wear of materials having adequate corrosion resistance is a problem of considerable magnitude. Choice of materials is governed by the possession of a combination of properties involving both wear and corrosion.

Early reactor designs made wide use of 18:8 steels because of the corrosion problems. However galling and seizing were so severe that it was impossible to use 18:8 nuts and bolts larger than ½ in. in diameter. Therefore a simulated wear test was devised to investigate the problem.

To evaluate the relative performance of materials combinations, the experimental data were reduced to a common term, called a "wear factor", which was expressed as milligrams weight loss per pound load per million cycles.

The material combinations shown in an accompanying table were selected to cover the full range of wear-factor values observed during these tests. They are arranged in descending order of usefulness.



Exploded view of piston-cylinder wear tester.

Test Procedure

Two types of tests were chosen as being representative of the sliding motions expected in service. One was a piston and cylinder combination involving pure linear motion, the other a sleeve bearing journal combination giving rotary motion. (*Editor's note—This condensation covers only tests made with the piston-cylinder device*).

The testing apparatus is shown in a photograph. Test specimens consisted of cylinders, 1.000 in. o.d. by 0.7500 in. i.d. by 1.250 in. long and pistons, which were split to allow radial spring loading, were 0.7470 in. o.d. by 0.500 in. long. Tests were made in stainless steel autoclaves at 500 F in pure water (minimum resistivity 500,000 ohm-cm) containing 2 to 25 cc per liter of dissolved oxygen. The duration of the tests were approximately 500,000 cycles with specimen under a 3-lb radial load.

Nitrided surfaces had the greatest wear resistance and antigalling characteristics of all materials tested. However, nitrided chromium and nitrided titanium were the only materials which had sufficient corrosion resistance in water to be usable.

The next best material in wear resistance was hard industrial chromium plate. This could be used successfully with a wide variety of mating materials. Corrosion resistance is assured by plating on a base of stainless steel. No other corrosion resisting material was found which approached the wear resistance of this plate. The benefit of using chromium plating can be seen by comparing the wear factor of Armco 17-7PH running against itself (460) with the value when one member is plated (20).

Excellent wear resistance was found with straight chromium steels as compared with the nickel-chromium grades but the former were unsuitable for use in oxygenated water because of pitting corrosion. The nickel chromium steels are well known for their susceptibility to seizure and galling. Of this class of steel only the age-hardenable grades were usable even to a limited extent.

Surface finish is another variable which can affect the wear resistance and galling tendencies. When the mating materials differ greatly in hardness, it is important that the harder of the two have a good finish, otherwise wear is accelerated by continuous cutting action on the softer material, or by loading of the rough surface followed by abrasive wear. Under certain circumstances wear can be reduced by having a controlled degree of roughness on at least one of the mating surfaces. Reduction in friction often occurs simultaneously. Thus, as-plated chromium on as-plated chromium, with a surface roughness of 30 to 40 microinches has a low wear factor of 34. The same materials combination with honed surfaces, and 1.0 microinches roughness, has a much higher wear factor of 135.

Light sandblasting of large bolt threads made of 18:8 stainless steel was successful in preventing seizure. Furthermore, sandblasted journals or sleeve bearings made of materials which ordinarily seized would ope-

in High Temperature Water

rate, although the wear rates were still very high. It is believed that the interrupted surface produced by sandblasting prevented the propagation of welds into large-scale galling. It is galling which closes clearances, and results finally in seizure. The porous structure developed by powder-metallurgy techniques also presents an interrupted surface and results in the same type of benefit.

An appreciation of the effect of corrosion on wear may be obtained by comparing the wear factors listed in the two columns of the table. In the second column are the results of a number of tests, standard in every respect, except that a partial pressure of hydrogen was substituted for the oxygen-argon mixture. In almost every case a substantial reduction in wear factor is noted. The greatest change took place with those materials which are most susceptible to oxidation. Everdur No. 1012 (silicon bronze) versus chromium plate, for example, has a very low wear factor (2.2) in hydrogenated water and an extremely high factor (830), in oxygenated water. Likewise there was an 88% reduction in wear for the KR-Monel versus chromium-plate combination. In contrast, the stellite combinations, because they are more oxidation resistant, did not show improvements of this magnitude. The reductions ranged only from a few per cent up to a maximum of 50%.

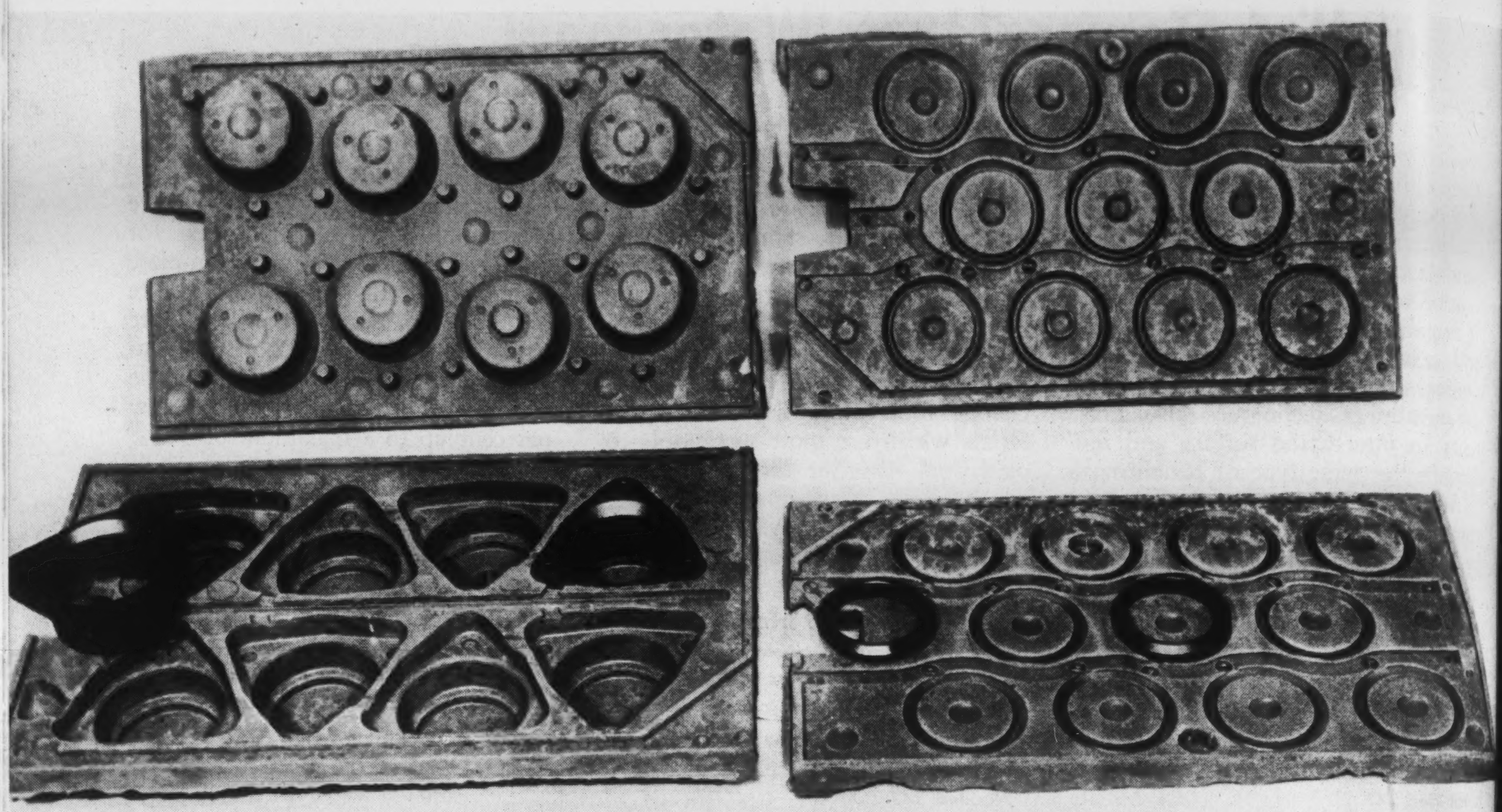
Adapted from a paper presented before the American Society Of Mechanical Engineers Semi-Annual Meeting, June 1954.

Piston-Cylinder Wear Tests Performed at 500 F in Water

Material Combinations		Mg loss in weight per lb load per million cycles	
Piston	Cylinder	Oxygenated Water	Hydrogenated Water
Nitrided 347	Nitrided 347	0.0	—
Nitrided chromium plate	Nitrided chromium	0.0	—
As-plated chromium plate	Nitrided titanium	4.7	—
Metamic LT-1	Nitrided Armco 17-4PH	7.0	—
Honed chromium plate	Stellite No. 3	8.3	0.3
440C	440C	15	—
410	Stellite No. 3	16	—
Honed chromium plate	Kentanium K-151	16	—
Honed chromium plate	Armco 17-4PH	20	13
Honed chromium plate	Nitrided Armco 17-4PH	22	—
Stellite No. 1	440C	23	—
Stellite No. 12	Honed chromium plate	25	—
Stellite No. 6	Stellite No. 6	27	—
Nitrided Armco 17-4PH	Nitrided titanium	28	—
U. S. Steel Type W (SA)	Stellite No. 3	31	—
Wall Comoloy No. 6	Stellite No. 6	32	—
As-plated chromium plate	As-plated chromium plate	34	—
Armco 17-4PH	Honed chromium plate	35	11
Haynes No. 21 (SA)	Stellite No. 6	39	—
Carboloy 608	Honed chromium plate	41	—
Haynes No. 21 (SA)	Haynes No. 21 (SA)	51	19
Stellite No. 3	Honed chromium plate	55	—
Stellite No. 3	Wall Comoloy No. 6	61	60
Armco 17-4PH	Stellite No. 6	62	—
Honed chromium plate	Stellite No. 6	65	24
Stellite No. 3	Stellite No. 3	71	34
Armco 17-4PH	Carboloy 608	72	—
Metamic LT-1	Metamic LT-1	76	—
Stellite No. 3	Haynes No. 25 (CW)	77	47
KR-Monel	Honed chromium plate	81	1.1
Stellite No. 1	Stellite No. 6	88	—
Haynes No. 21 (PH)	Haynes No. 21 (SA)	98	—
Haynes No. 21 (SA)	Honed chromium plate	102	28
Honed chromium plate	Haynes No. 25 (CW)	105	—
Stellite No. 3	Armco 17-4PH	115	33
Haynes No. 21 (PH)	Haynes No. 21 (PH)	120	—
U. S. Steel type W	Stellite No. 3	130	11
Honed chromium plate	Honed chromium plate	135	—
Honed chromium plate	Hastelloy D	140	45
304	As-plated chromium plate	150	—
Armco 17-4PH	Stellite No. 3	150	25
KR-Monel	Stellite No. 3	170	31
Stellite No. 3	Hastelloy D	300	43
Armco 17-4PH	Armco 17-4PH	460	—
Everdur 1012	Haynes No. 21 (SA)	660	18
Stellite No. 3	Armco 17-4 (SA)	700	—
Everdur 1012	Honed chromium plate	830	2.2
304	304	3200	—

SA—Solution annealed.
PH—Precipitation hardened.
CW—Cold worked.

Arbitrary classification of materials	*Mg loss*
Excellent	*up to 25*
Good	*25 to 50*
Fair	*50 to 100*
Poor	*100 to 200*
Unusable	*over 200*



GRAY IRON *exhaust pipe flanges and exhaust seal rings made by shell molding method.*

International Harvester Finds . . . .

Gray Iron Shell Mold Castings

- ***Stronger for thin castings***
- ***Better in surface and dimensional accuracy***
- ***Lower in overall production costs***

by **KENNETH ROSE,** Mid-Western Editor, Materials & Methods

● GRAY IRON CASTINGS produced by shell molding at International Harvester Company's Truck Engine Works at Indianapolis are showing definite advantages over conventional sand castings that can be translated into cost savings and improved quality. As a result, the company's engineers foresee a much wider use of the method in the future, possibly reaching as much as 10% of all of the company's castings.

Company findings agree with the general opinion that Contour Molding, International Harvester's trademarked name for its shell molding process, is slightly more costly in the foundry than older methods, in spite of the economies of mechanization obtainable with shell molding. However, supplementary savings outside the foundry tip the balance in favor of shell molding by showing an overall saving. These savings are in machining costs, and are the result of the smooth surface and closer dimensional tolerances obtainable with shell molding. In the case of one of the parts, an exhaust seal ring, the part when cast in green sand molds was machined all over; it is now produced by shell molding with such surface and dimensional accuracy that machining has been eliminated.

After several years of experience with shell molding, both in research and in production, International Harvester engineers have come to the conclusion that gray iron castings that are at least twice the weight of the two shells will in general be practicable for shell molding, disregarding such considerations as better finish and greater dimensional accuracy. If no backing is used, the ratio may be lower. Other authorities have carried this weight ratio as low as 1.7.

Four castings are now being produced as gray iron shell mold castings. They include two exhaust seal rings, and two exhaust pipe flanges. The need for more shell molding production facilities has already been recognized, as the success of the process becomes more clearly apparent.

In addition to the four pieces now in production by shell molding, the Indianapolis plant intends to purchase a second mold-making machine and begin production of flywheel castings. The engine side of the flywheel as now being made must be machined, and all of this machining operation can be eliminated by the change in casting methods. Installation is now awaiting tooling changes in the machine shops to permit other machining operations on the new castings. When ready for production, the shell molded flywheels will require the entire capacity of one shell molding line. Experimental work for the flywheel production setup has shown that a complete cycle of slightly less than 3 min. is satisfactory. Changes now being incorporated in the pre-heat cycle in the ovens are expected to reduce the time for a complete cycle to about 90 sec per shell.

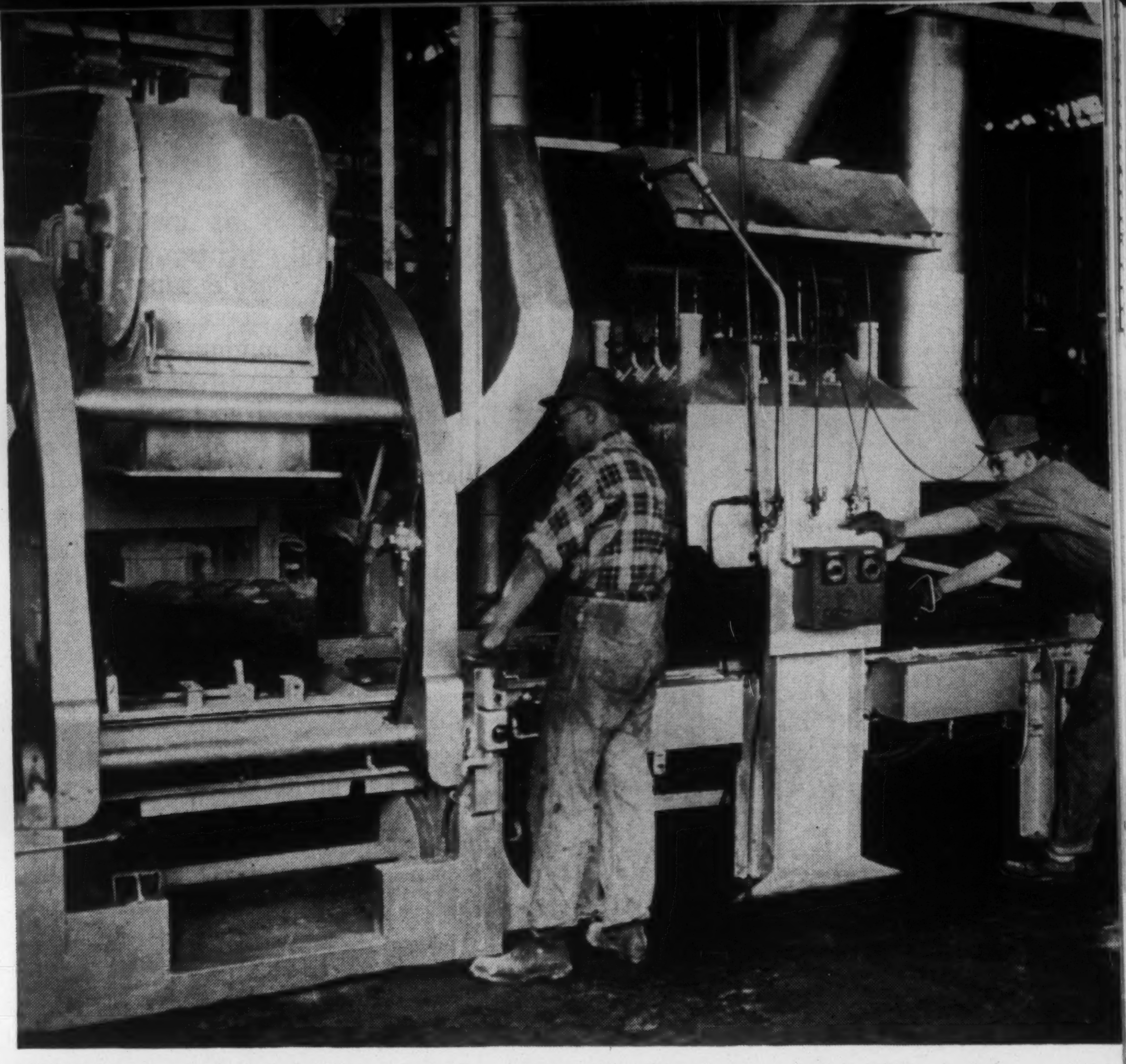
Advantages

The metal now being cast in resin bonded shells is gray iron of about 3.35% carbon and 2% silicon. Some of the advantages shown by the company's experience are:

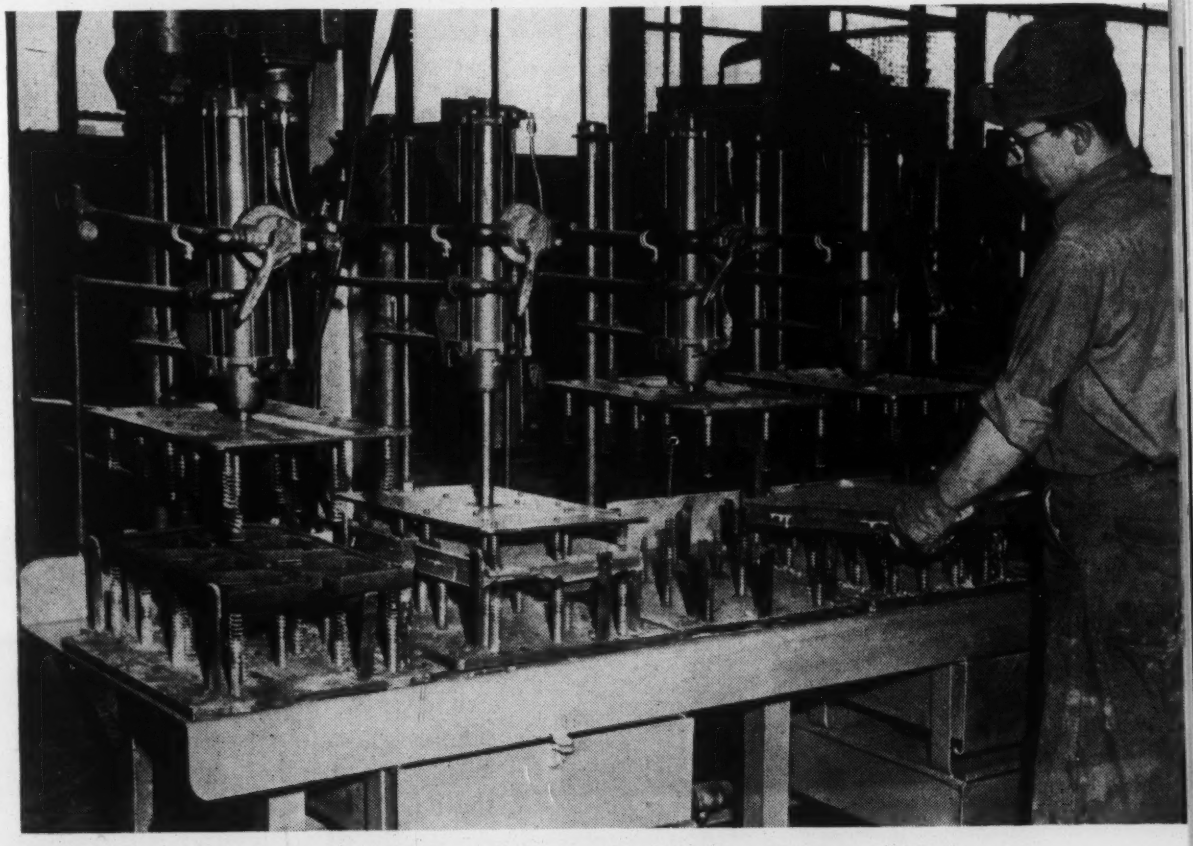
1. In thin castings, shell molded pieces are stronger for the same chemistry than green sand castings.
2. Shell castings are much more machinable, especially in turning, milling and broaching.
3. The closer tolerances possible with shell molding means less metal allowed for finish machining.
4. The cleaner castings increase tool life.
5. Less metal is required for sprues and gates.
6. The castings shake free of molding sand, and require less cleaning.
7. There is less tendency to chilling in the shell molded pieces.

The strength difference becomes quite apparent in the case of machined green sand castings and shell molded pieces that do not require machining. Machining removes the toughest part of the cast iron, giving the shell molded pieces a substantial advantage. As an example, International Harvester found that in spin tests with a gray iron flywheel molded in green sand and machined to size, the piece flew apart at 8500 rpm whereas a shell molded flywheel withstood 10,000 rpm, the highest speed possible with the testing machine, without failure.

Efficiency in production is an important part of the success in keeping costs to a point that makes the process economically feasible. Production of the shells is a one-man operation, using a molding machine designed by company engineers. Patterns are of aluminum and of steel, a standard 20 in. by 24 in. The com-

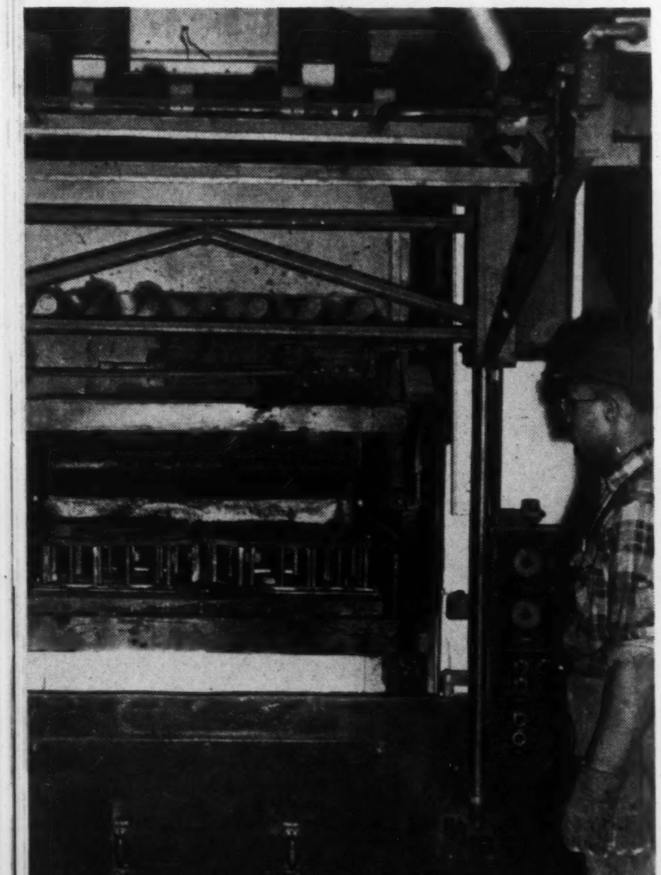


MOLDS *for two exhaust seal rings and two exhaust pipe flanges are made in this special machine built at Indianapolis Works of International Harvester Co.*



ADHESIVE *is applied to two mold halves and assembled in these presses while they are still hot to get a fast set-up of the adhesive.*

MOLDS in FLASK over a common runner bar ready to receive sand to back-up mold for pouring.



FLYWHEEL CASTING molds are made on this machine.

pany produces its own aluminum patterns, and purchases the steel patterns from outside suppliers. Steel patterns cost about $5000 apiece. While the aluminum patterns are much lower in cost, they are not as long-lived. Both materials give satisfactory service when the system operates properly, but several aluminum patterns were damaged when the conveyor lines through the oven stopped and permitted local overheating.

Making the Molds

At the beginning of the mold-making cycle, the first pattern, heated from 450 to 500 F, moves out of the oven and under the shell-making machine on a conveyor. A box, open at top and bottom, fits around the top of the pattern, and a gate in a cylinder above the pattern opens to sift the sand-and-resin mixture over the pattern. The drop is only about 7 in. A shell of sand about 3/16 to 1/4 in. thick forms over the pattern by the action of the heat of the pattern upon the phenol-formaldehyde resin. Dwell time is about 13 to 15 sec., after which the entire unit of pattern, box and sand cylinder rotates vertically through 180 deg to dump the unbonded sand back into the cylinder. The unit then rotates back to the original position, the gate in the sand cylinder now being closed, and the box is raised and pattern and shell move out of the machine on the conveyor to the next station. Here the pattern and shell are raised on an air lift to a small gas-fired curing oven that fits snugly over the top of the pattern. Oven temperature is about 900 F, and cure continues for about 28 sec., with the pattern temperature reaching about 450 F. Pattern and shell are then lowered on the air lift to the conveyor, and the cured shell is stripped from the pattern. The pattern continues on the conveyor to the entrance of the oven where it is automatically sprayed with a silicone parting liquid, and the shell is mated with its opposite half. A streak of polyvinyl adhesive is placed along the edges of the shell to bond the halves together, and the mold is placed in a spring-loaded clamping device until the adhesive sets. Finished molds are then moved to the pouring floor.

The pattern, cooled about 100 to 150 F in the air, moves into the first section of the heating oven to be brought up to the 450 F that is desired as initial temperature. The oven is in three sections, at right angles to each other, so that they form three sides of a rectangle and discharge the heated pattern at the beginning of the shell-making cycle. The first section is heated by infrared lamps, and the remaining two are gas-fired to bring oven temperature to about 900 F. Travel time for a pattern through the oven is $4\frac{1}{2}$ min.

About 8 patterns would be required to fill the system properly. This would produce a shell every 45 sec. When this number is not available, the process cannot operate at its best speed. Occasionally patterns come through that have not had sufficient time in the furnace to come to temperature, and it is then necessary to recycle them without making a shell.

Making the Castings

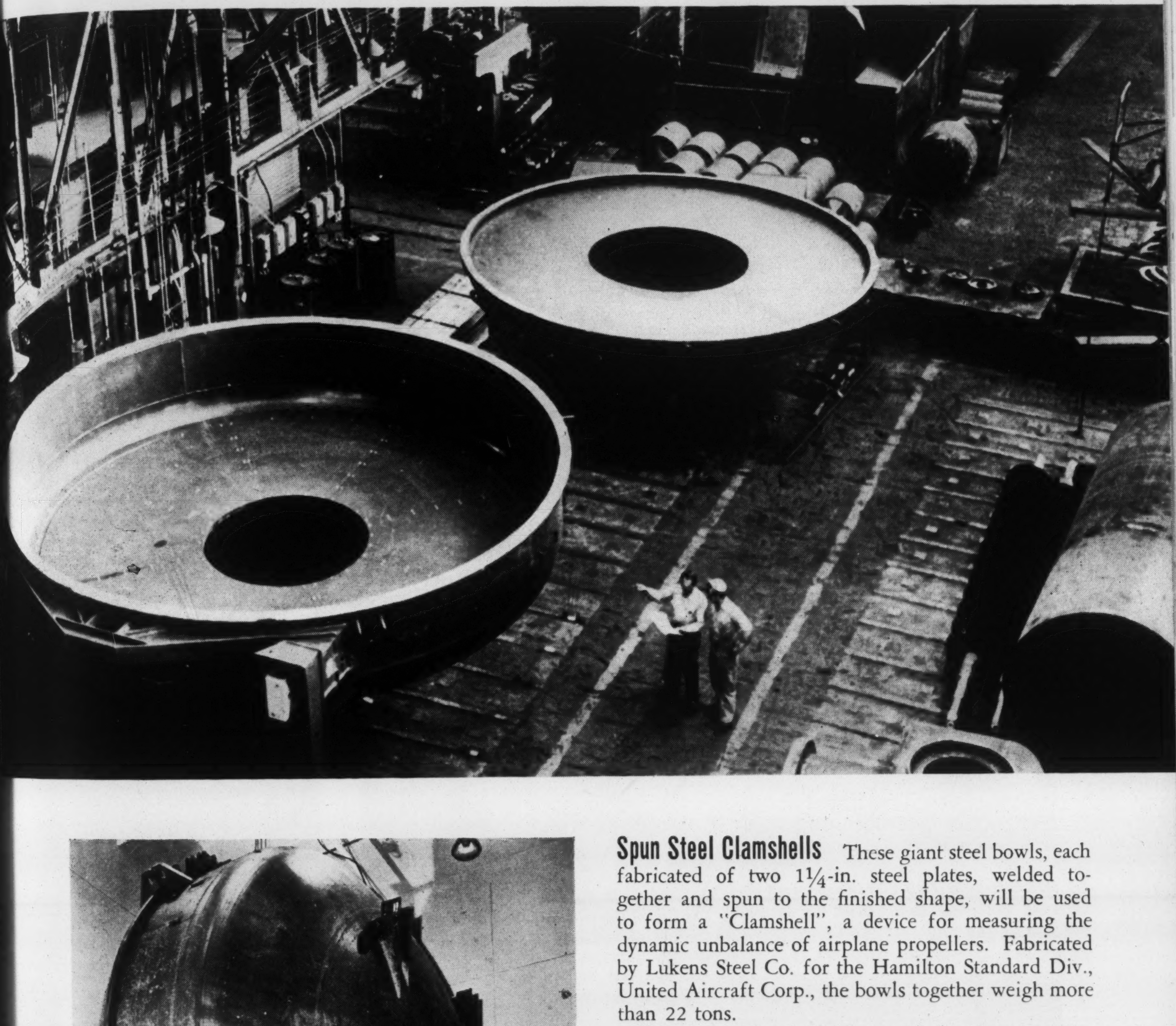
All shell molds are backed by foundry sand. Six molds are inverted in a steel flask over a runner bar, foundry sand is thrown into the flask from a sandslinger, and jolted to fill the flask evenly. When the flask is rolled over, the runner bar has joined the gates on all six shell molds so that one pouring fills the six shells. Each flask produces 66 rings, 11 to the shell. Pouring is done from overhead ladles in the usual way. After cooling, the flask goes to shakeout and the parts are ready for the cleaning department. No attempt is made to separate the sand from the shells and the sand used for backup; after conditioning, all is returned to the floor for use in conventional molding.

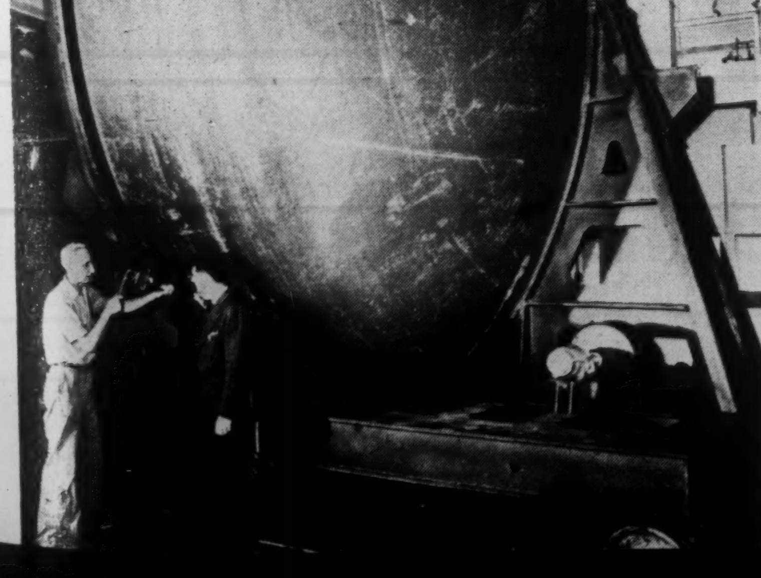
The sand for shell molding is quite fine, of AFS No. 120 and gives sharp detail and fine surface to the cast pieces. Resin content is 7%. It has been found that the pieces as-cast are actually smoother in surface finish than the pieces after shot blasting, and intentions now are to shift to a somewhat coarser sand, of about AFS No. 80 to 90. In this way, it is expected that the pieces will be made very slightly rougher when cast, but that shot blasting will improve the surface somewhat. The change to the coarser sand will make possible a reduction in resin content also.

To take care of short runs of the parts being produced by shell molding, it is estimated that about 15 patterns would be required for each machine. By keeping all patterns standard at 20 in. by 24 in., different patterns can be run through the mold-making machines, and several different shell molds can be placed in the same flask for pouring.

Materials at Work

Here is materials engineering in action . . .
New materials in their intended uses . . .
Older, basic materials in new applications . . .





Spun Steel Clamshells These giant steel bowls, each fabricated of two 1¼-in. steel plates, welded together and spun to the finished shape, will be used to form a "Clamshell", a device for measuring the dynamic unbalance of airplane propellers. Fabricated by Lukens Steel Co. for the Hamilton Standard Div., United Aircraft Corp., the bowls together weigh more than 22 tons.

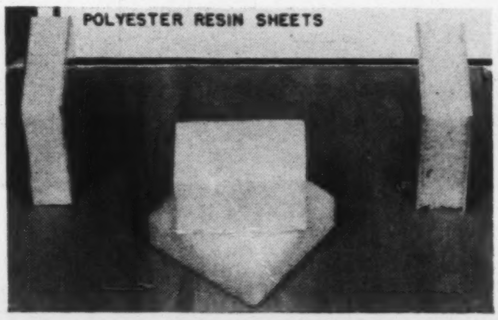
When the Clamshell is assembled with a propeller mounted inside, a vacuum will be drawn, and the propeller spun. Any imbalance of the propeller can be measured and proper weights can be added to correct it.

Propellers up to 19½ ft in diameter can be tested in the unit, and air can be evacuated from the chamber to simulate the pressures encountered at altitudes up to 115,000 ft. A 125-hp motor will furnish sufficient power to turn the propellers at flight speeds.

Ingredients of a Giant

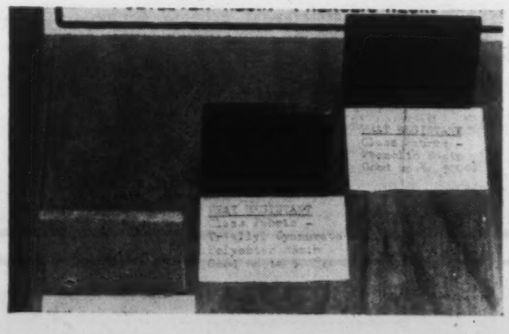
These are some of the newer materials which at various stages of development have passed through the Materials Laboratory of the Wright Air Development Center. Some were developed at the Laboratory itself—some under contract—all have been approved for use on the B-52 Stratofortress.

SILICONE TUBE AND COVER *reinforced with steel and glass fiber. Used for air-bleed hose at 500 F.*

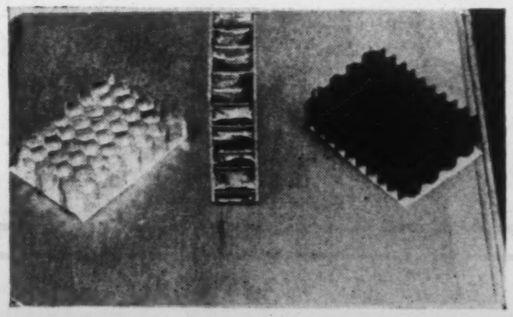


FOAMED-IN-PLACE PLASTIC *core material between aluminum and plastic-glass sheet. Used for radomes and control surfaces.*

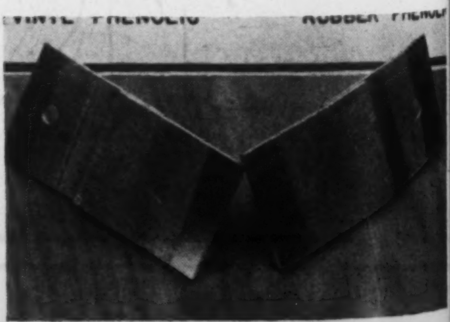
TITANIUM SHEET FROM SPONGE. *Used for skins and bulkheads, firewalls and compressor sections.*



STRUCTURAL PLASTIC; *(left to right) glass reinforced conventional polyester, heat resistant polyester (500 F), and heat resistant phenolic (500 F). Used for radomes, heating ducts and fuel tanks.*



SANDWICH STRUCTURE *uses combinations of aluminum, glass fabric and heat resistant resins for skins and honeycomb core. Used for aircraft skins, stiffeners and radomes.*



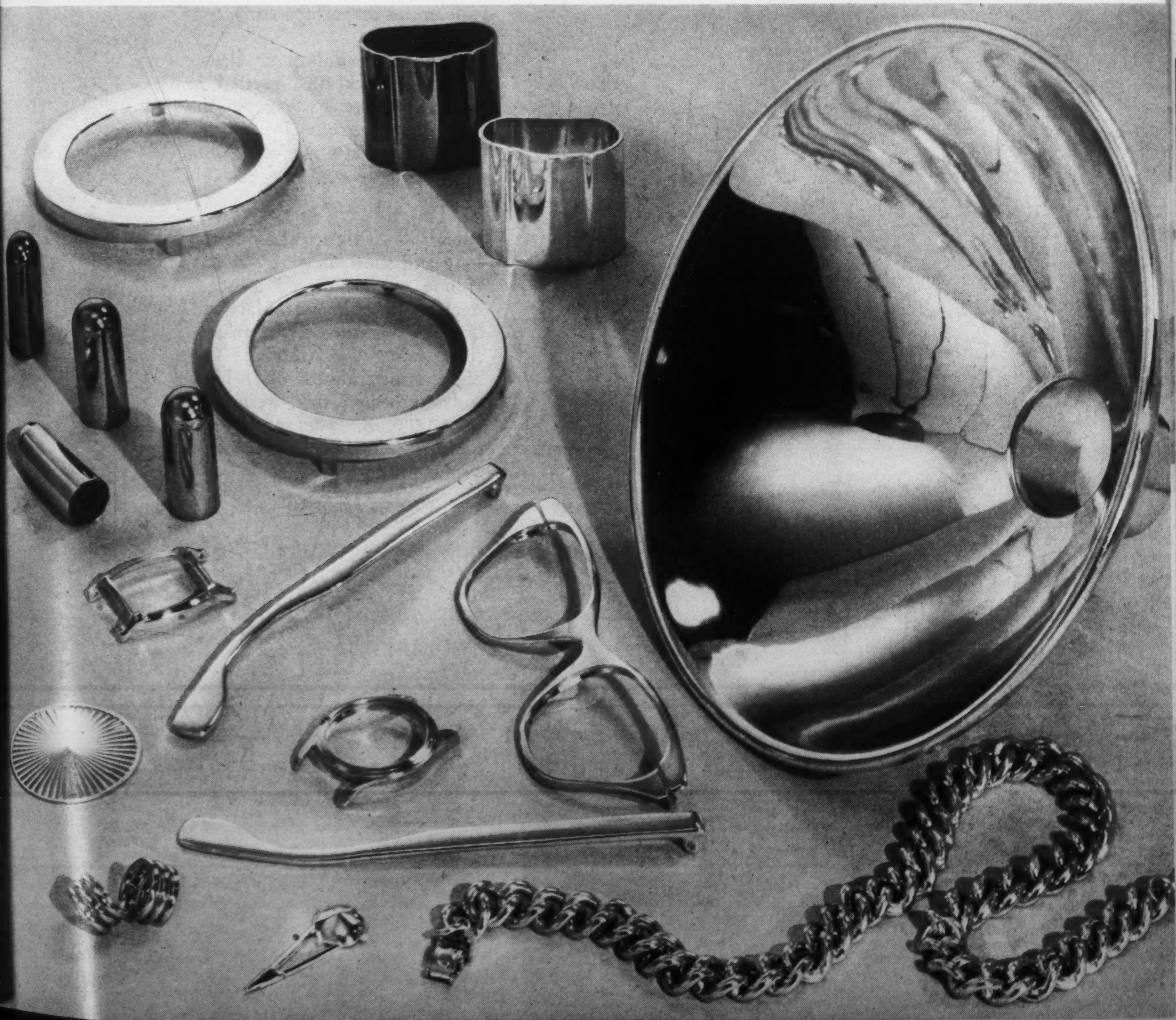
STRUCTURAL ADHESIVES *of vinyl phenolic or nitrile rubber phenolic bond aluminum to aluminum. Used in aircraft skins or in helicopter blades.*

Aluminum Tape This glistening tape is a new aluminum foil pressure-sensitive tape for industrial sealing, splicing, electroplating, conduction and heat reflection jobs now being produced by Minnesota Mining and Mfg. Co. It is made of a dead-soft aluminum foil backing coated with a high-tack thermosetting type of adhesive.

Average property values for the tape are said to include a tensile strength of 32 lb per in. of tape width, elongation of 15% at breaking point, adhesion of 60 oz per in. of tape width, and a moisture-vapor barrier of 0.1 gm per 100 sq in. per 24 hr at 100 F. The tape is said to be unaffected by extreme humidity conditions and to have high heat reflection, weathering, moisture resistance, and conductivity characterisitcs.

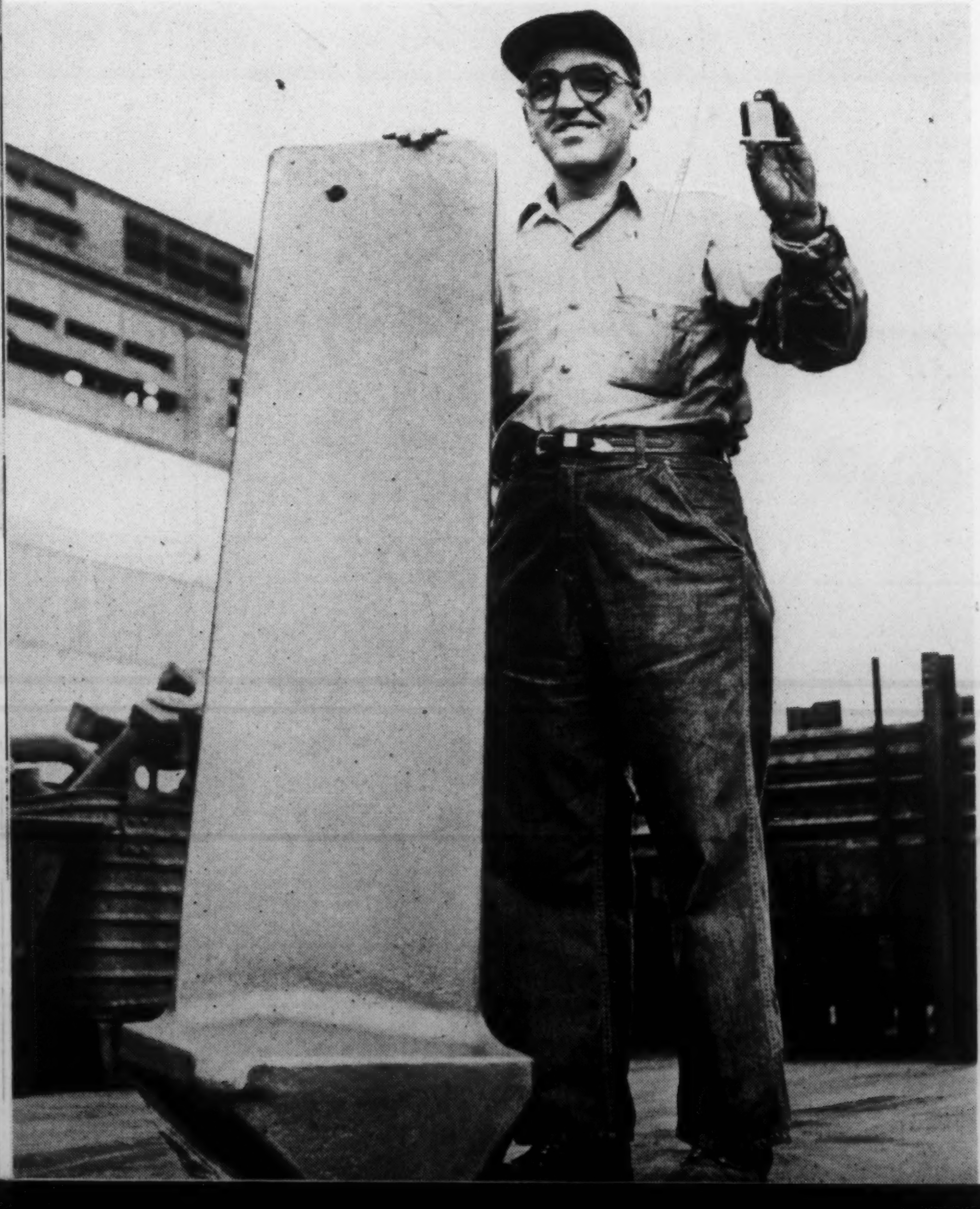
Aluminum Luster These glittering parts, representing a wide variety of metal forming methods, are made of Lurium, high purity (99.9%) aluminum, finished by the Lurbrite process. The eyeglass frames are forged, the lipstick containers deep drawn, the napkin rings extruded, the radio dial disks stamped, the dial pointers stamped and formed, the watch cases machined from extrusions, the reflectors spun and the wire bracelets drawn.

Because of its high purity the material can be polished, anodized and dyed to a mirror-like finish in several colors. It can be made to simulate gold, silver, platinum, brass and other metals, as well as a multitude of other colors.

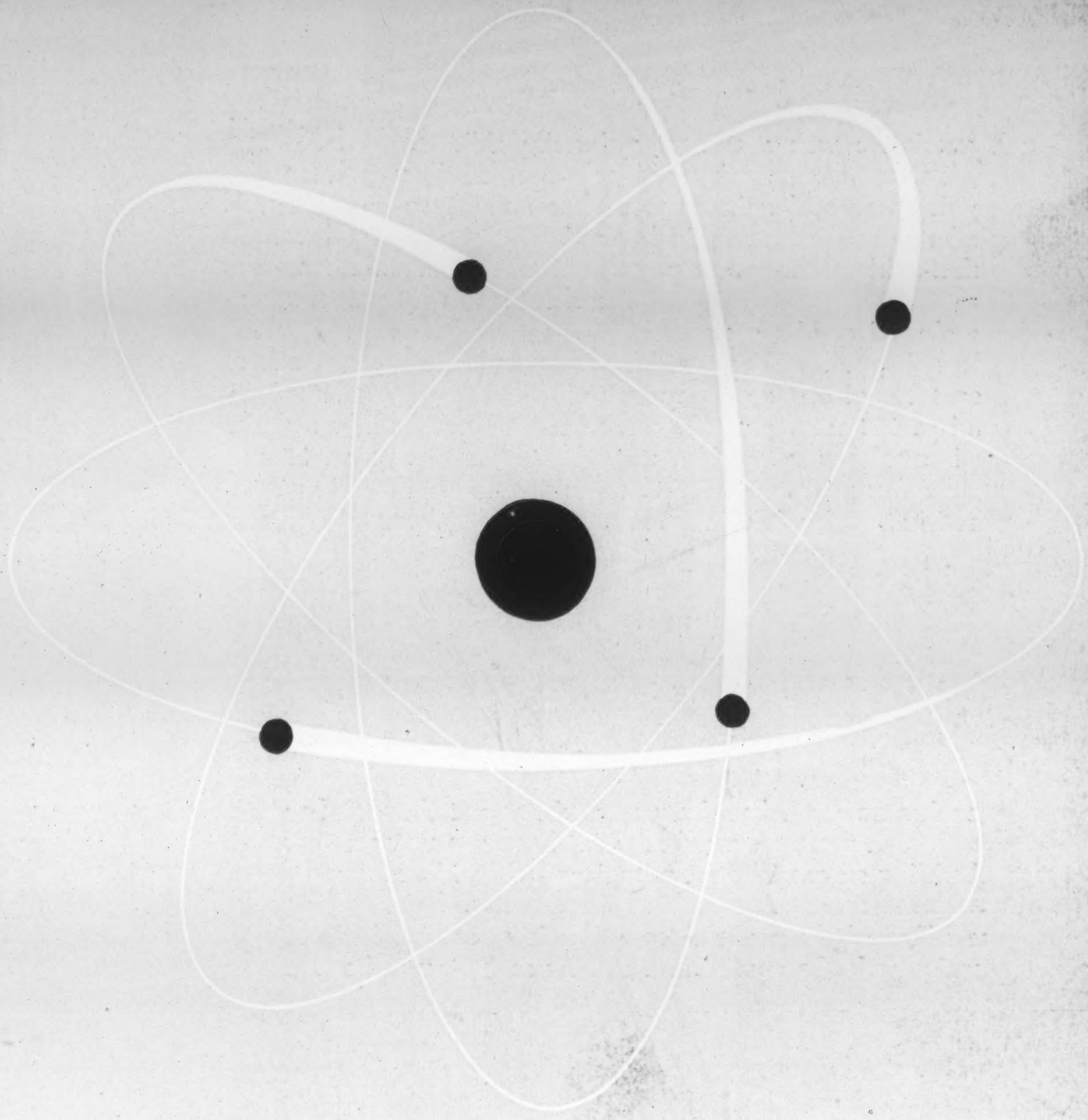


Big Titanium Valve Built to handle highly corrosive fluids under conditions of high service pressures, this titanium and silver diaphragm control valve cost $10,000. Manufactured by Minneapolis-Honeywell's Valve Div., the trim of the valve was machined from solid titanium, and will last for around 70 days under the severe operating conditions.

The silver lining, or sleeve, 3/32 in. thick was inserted in the inlet bore to increase the body life. Corrosion is estimated to take place at a rate of 1/1000 of in. per day.



All Sizes This seems to be the long and short of it . . . at left is one of the forged stainless steel blades being manufactured by Kropp Forge Co. for an aircraft testing wind tunnel. The blade stands almost 5 ft high and represents a total weight of over 1100 lb. The small compressor rotor blade at right weighs only ¼ lb.



How Nuclear Radiation Affects Engineering Materials

by **D. O. LEESER,** Reactor Engineering Div., Argonne National Laboratory

MATERIALS & METHODS

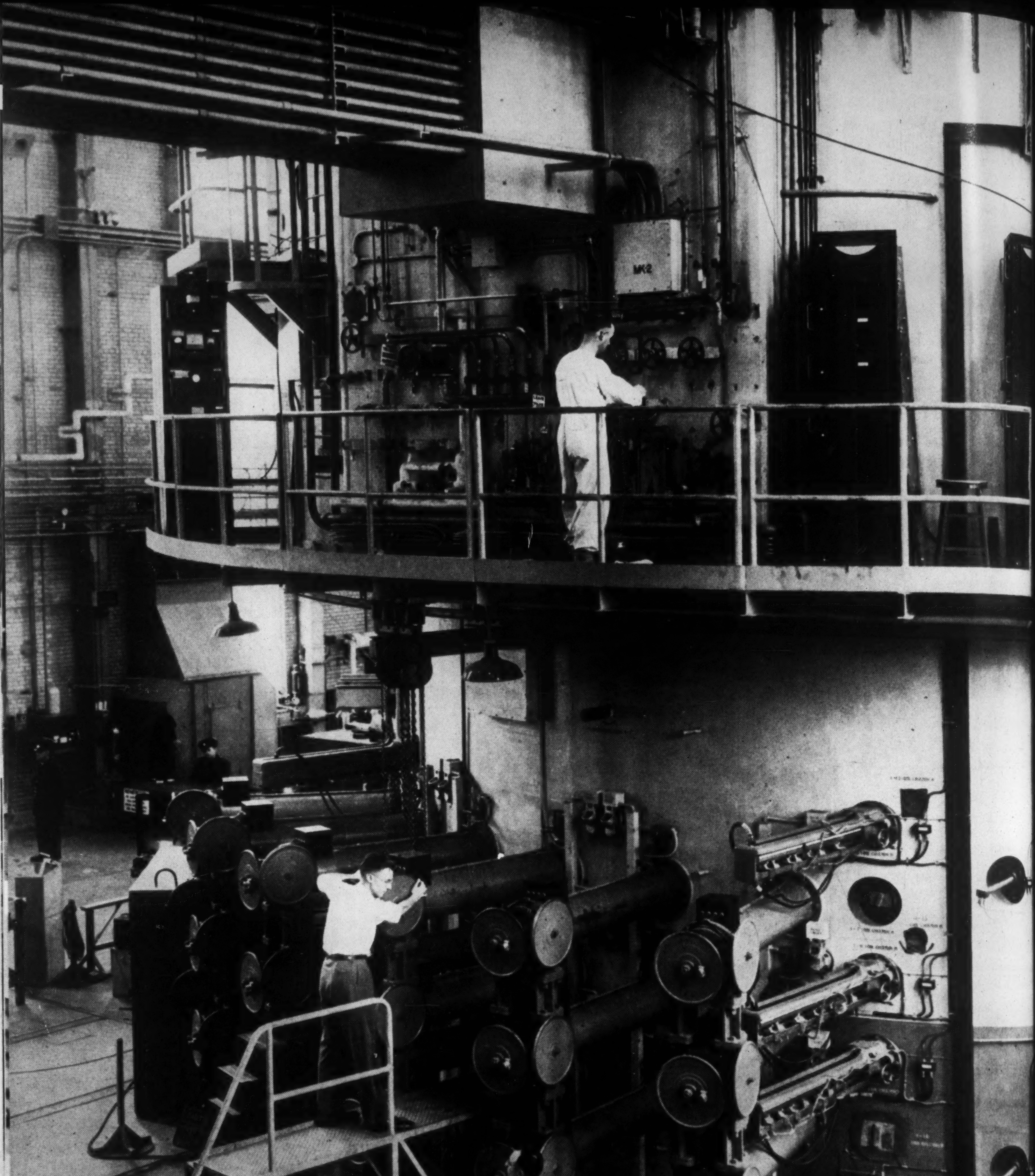
Manual No. 107

This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and applications.

AUGUST 1954

Engineering materials going into the construction of atomic power reactors must not only be able to withstand heat and highly corrosive conditions, but also bombardment by nuclear particles. This manual provides a preliminary survey of how a number of structural engineering materials behave when subjected to nuclear irradiation. It covers:

- *Effect of Radiation on Mechanical and Physical Properties of Metals*
- *Effect of Radiation on Some Nonmetallics*
- *Neutron Absorption*



The Chalk River nuclear fission chain reactor in Canada uses heavy water as moderator. (*AEC Photo*)

Introduction

● THE PERFORMANCE OF engineering materials is now being judged by a new criterion—resistance to radiation damage. In the last few years industry has entered the study and development of atomic reactors for central power stations. It is evident that further peace-time uses for nuclear reactors will be found. In these applications, conventional properties, such as strength, high temperature performance and corrosion resistance are still important. But complete evaluation of the materials must now also include consideration of the effects of bombardment by nuclear particles thrown off during irradiation processes.

As in most structures successful construction of a nuclear reactor depends, to a large extent, on the proper choice of materials. The reactor, with only the chain-reacting fuel, could not be successfully controlled if the operating mechanism and auxiliary structures were not included in the design. Operating mechanisms, usually actuated by controlled servo devices, include the use of materials for gears, bearings, control rods, springs, instruments, electrical connectors, etc. The auxiliary structures and plant include materials for pressure vessels, piping, closures, valves, pumps, welds, and other similar equipment.

There is little doubt that carbon steels, stainless steels, and non-ferrous metals and alloys of cobalt and nickel will constitute a large portion of the structural materials in presently anticipated power reactors. Consequently, it has been deemed essential to carry on a preliminary experimental study to ascertain that the above selected materials will perform satisfactorily in radiation service.

The information in this article is drawn from the results of these preliminary studies. No attempt has been made to draw any specific conclusions from the data presented. They are only indications and must be treated as such.

Mechanism of Radiation Damage

The mechanism of radiation damage is highly complicated. A simplified version of the theory is given in the accompanying box (p. 116).

The exact nature of organic-chemical changes due to radiation damage, such as those found in synthetic plastics, has not been analysed completely. Here the damage due to the initial displacement of atoms is masked by damage due to ionization and excitation processes.

Radiation damage in metals has been interpreted as similar to the effects of cold work, with two important exceptions: 1) the effect is applied on a microscopic or extremely localized scale; and 2) the effect is non-directional. However, recent investigations have challenged the analogy, and the mechanism of radiation hardening is explained as not having a direct correspondence to cold work, but being somewhat more analogous to solid-solution hardening. Whatever the interpretation, the fact remains that in their traverse through materials nuclear particles may cause mechanical and physical changes. These changes are known as radiation damage and may be large when compared with the small amount of energy required to produce the damage. This is analogous to the effect of a lethal dose of gamma rays which raises the body temperature only 0.002 to 0.004 F, while an accidental electrocution may instantaneously burn the body.

Effect of Radiation on Mechanical Properties

Hardness

Tables 1, 2, and 3 show the effect of various radiation intensities on the hardness of plain-carbon steels, stainless steels, nickel-base alloys and cobalt-base alloys when irradiated at various ambient temperatures. An accompanying chart includes zirconium and compares the effect of various irradiation dosages on these groups of metals.

From the data on carbon and stainless steels, it is apparent that:

1. Steels in the soft condition show greater hardening due to irradiation than do harder materials.
2. Radiation damage is not a direct function of carbon content.
3. The effects of irradiation are preserved at room temperatures.
4. The effects of irradiation proceed at a decreasing rate and probably approach a limit well below the fully embrittled condition.

An indication that irradiation effects

Table 1—Effect of Irradiation on Hardness of Carbon Steels

Material	Treatment or Condition	Radiation Exposure, nvt	Brinell Hardness (Converted)	
			Before Irradiation	After Irradiation
1018	Annealed	1	174	183
1018	Annealed	1	156	168
1018	Hardened	1	241	247
1018	Annealed	2	138	161
1018	Hardened	2	237	243
1042	Annealed	1	201	207
1042	Annealed	1	236	270
1042	Hardened	1	430	444
1042	Annealed	2	225	187(a)
1042	Hardened	2	390	426
1045	Annealed	3	187	187
1045	Hardened	3	514	370(b)
1095	Annealed	1	297	311
1095	Hardened	1	542	550
1095	Annealed	2	290	315
1095	Hardened	2	535	535
1113	Annealed	1	195	217
1113	Hardened	1	190	195
1141	Annealed	1	220	255
1141	Hardened	1	421	430

1. nvt of $1x10^{19}$ slow at 450–500 F.
2. nvt of $2x10^{19}$ slow and $7x10^{18}$ fast at 70–140 F.
3. nvt of $3x10^{20}$ slow and $1x10^{20}$ fast at 70–80 F.

[a] *No explanation for decrease in hardness values.*

[b] *Decrease in hardness due to corrosion products caused by leaking container.*

Table 2—Effect of Irradiation on Hardness of Stainless Steels

Material	Treatment	Radiation Exposure, nvt	Brinell Hardness (Converted) Before Irradiation	Brinell Hardness (Converted) After Irradiation
304	Annealed	1	131	131
304	Malcomized	2	654	810
309	Annealed	1	152	158
316	Annealed	2	154	228
316	Annealed	1	143	143
316	Cold Worked	2	226	285
329	Annealed	3	158	158
347	Annealed	3	183	183
347	Malcomized	4	656	656
347	Annealed	1	152	152
347 (Cb-Ta)	Annealed	3	153	175
347 (Cb-Ta)	Shot Peened	3	153	168
410	Malcomized	2	656	740
410	Malcomized	4	688	688
410	Malcomized	5	739	739
431	Annealed	3	277	331
431	Hardened	3	371	400
440 C	Hardened	5	461	534
440 C	Hardened	2	545	545
440 C	Hardened	5	388	415
440 C	Malcomized	4	577	800
442	Annealed	3	185	223
446	Hardened	3	200	250
U.S.S. "W"	Hardened	2	461	461
U.S.S. "W"	Hardened	3	415	440
Armco 17-4PH	Annealed	6	315	477
Armco 17-4PH	Hardened	3	415	440
Armco 17-4PH	Hardened	6	403	432
Armco 17-7PH	Hardened	3	415	460
Armco 17-7PH	Hardened	6	477	477
Armco 17-7PH	Malcomized	3	740	820

1. *Calculated nvt of 1.2x10^{19} slow. Exposure in 400–500 F flowing water.*
2. *Calculated nvt of 3.7x10^{20} slow and 5.1x10^{20} fast. Irradiated at 70–80 F.*
3. *Calculated nvt of 3x10^{19} slow. Exposure in flowing water at 540 F.*
4. *Calculated nvt of 10^{19} slow. Dry exposure.*
5. *Calculated nvt of 5x10^{19} slow and 4x10^{19} fast.*
6. *Calculated nvt of 4.4x10^{19} slow in 540 F flowing water.*

Table 3—Effect of Irradiation on Hardness on Nickel and Nickel Base Alloys

Material	Condition	Radiation Exposure, nvt	Brinell Hardness (Converted) Before Irradiation	Brinell Hardness (Converted) After Irradiation
Nickel A	Annealed	1	64	137
Hastelloy C	Cast	2	228	360
Hastelloy C	Cast	2	170	228
Hastelloy C	Wrought	1	255	285
Hastelloy C	Wrought	3	209	209
Hastelloy C	Wrought	4	256	275
Monel	Annealed	3	150	209
Monel	Annealed	4	157	180
K-Monel	As-received	3	260	285
K-Monel	As-received	4	255	265
K-Monel	Annealed	5	148	180
K-Monel	Hardened	5	341	341
Inconel	As-received	3	175	240
Inconel	As-received	4	180	228
Inconel X	Annealed	3	209	265
Inconel X	Annealed	4	219	247

1. *Calculated nvt of 1x10^{19} slow. Exposure in 400–500 F flowing water.*
2. *Calculated nvt of 4x10^{19} slow and 5x10^{19} fast.*
3. *Calculated nvt of 5x10^{19} slow and 4x10^{19} fast at 70–140 F.*
4. *Calculated nvt of 4x10^{19} slow. Exposure in 540 F running water.*
5. *Calculated nvt of 3x10^{19} slow. Exposure in 540 F running water.*

approach a saturation level is illustrated in the tabulation below where it is significant that the hardness of similar materials in three conditions of heat treatment are within five points Rockwell C after irradiation.

	Rockwell C	*Hardness*
Material	*Pre-Irradiation*	*Post-Irradiation*
Armco 17-4 PH	33-35	48-52
Armco 17-4 PH	43-44	44-48
Armco 17-7 PH	50-51	48-50

All the nickel alloys show an increase in hardness. However, as in the case of the other materials, the amount of increase is governed by the ambient temperatures; that is, the higher the ambient temperature the lower the increase in hardness. Hardness changes on tungsten and a tantalum-tungsten alloy are insignificant. Tantalum hardness increases about 20 points Bhn.

Tensile Strength

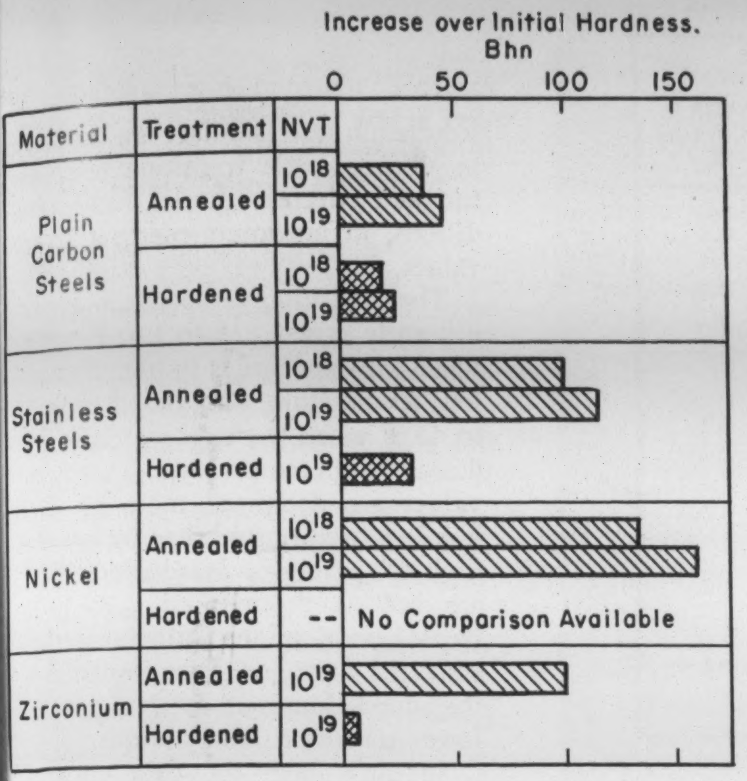
The effect of reactor irradiation on the tensile properties of stainless steels, nickel-base alloys and high-density materials is shown in Table 4. From these results we see that radiation damage effects on tensile properties can be annealed out by high ambient temperatures.

Where the temperature is above 500 F. there is a slight increase in yield and ultimate strengths and a slight decrease in ductility. However, in the case of age-hardening alloys, the effect of irradiation may be overshadowed by the effect of temperature aging. At lower temperatures beween 70-140 F, the tensile strengths increase as much as 13% and the ductility, as expressed by per cent elongation, decreases as much as 50%. In other words, those samples which are irradiated at elevated temperatures show less effect than those irradiated at essentially room temperature.

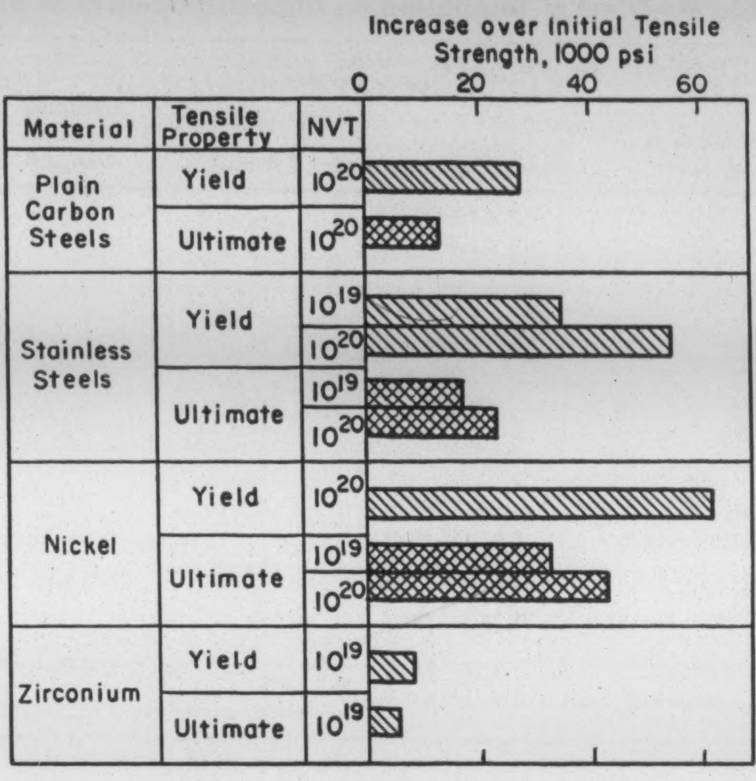
There is little appreciable chang due to irriation on the tensile strengt of Stellite 3. A scatter in test resul is probably due to alignment difficulties with brittle specimens by remot operation.

The tensile strengths of high-densit materials increase from 20 to 25% The ductility, as expressed by per cen elongation, does not change for tungsten but decreases 20 to 50% for tantalum and a tantalum-tungsten allo

The degree of change shown, i Table 4, is also related to the origina condition, or to the hardness, of th material rather than to the chemica analysis. The damage appears les



Effect of irradiation on hardness of some metals.



Effect of irradiation on tensile strength of some metals.

Table 4—Effect of Irradiation on Tensile Properties

Material	Treatment or Form	Radiation Exposure Conditions	Ultimate Strength, 1000 psi		Elong. in 2 in., %	
			Before Irradiation	After Irradiation	Before Irradiation	After Irradiation
STAINLESS STEELS						
304[a]	Annealed	1	92.5	92–95	70.8	41–58.5
309[a]	Annealed	1	95	99	54	51
316[a]	Annealed	1	90	89	70	66.5
347[a]	Annealed	1	99	103	56.6	54.5
316[b]	Annealed	2	79.5	151	—	—
U.S.S. Type "W"[b]	As-received	2	113	134	—	—
410[b]	Malcomized	3	69–70	70–75	—	—
440C[b]	Hardened	3	199–211	240	—	—
NICKEL BASE ALLOYS						
Monel[c]	As-received	4	127–131	133.5	—	—
Monel[d]	As-received	4	86–87	91.5	31–34	29
Monel[d]	As-received	5	85	96	33	10
K-Monel[c]	As-received	4	209–212	195	—	—
K-Monel[d]	As-received	4	124–127	133.5	9–12	19
K-Monel[d]	As-received	5	123	134	11	3
K-Monel[c]	As-received	5	211	226	—	—
Inconel[c]	As-received	4	148–153	160	—	—
Inconel[d]	As-received	4	107–108	113	28–33	29
Inconel[d]	As-received	5	106	116	31	29
Inconel[c]	As-received	5	151	172	—	—
Inconel X[c]	As-received	4	173–175	198	—	—
Inconel X[d]	As-received	4	128–129	139	35–38	35
Inconel X[d]	As-received	5	126	133	37	23
Inconel X[c]	As-received	5	174	203	—	—
Hastelloy C[c]	Wrought	4	192–204	191	—	—
Hastelloy C[d]	Wrought	4	138–142	137	19–21	36
Hastelloy C[d]	Wrought	5	138	142	20	12
Hastelloy C[c]	Wrought	5	198	220	—	—
Hastelloy C[d]	Cast	3	76–85	104–111	—	—
Nickel[a]	Wrought	1	64.5–67.5	69.5	44.8	34
Hastelloy C[a]	Wrought	1	139.5	142	53.5	42
HIGH DENSITY MATERIALS						
"Tantalloy"	As-received	6	136	163–167	29	14
Tungsten	As-received	6	145–160	102–132	0	0
Tantalum	As-received	6	65–72	85–88	19–23	17
"TantungG"	As-received	6	72.5	68.5–72	5	4

1. nvt of $1x10^{19}$ slow at 400–500 F in flowing water.
2. nvt of $3.7x10^{20}$ slow and $5.1x10^{20}$ fast at 70–80 F.
3. nvt of $4x10^{19}$ slow and $5x10^{19}$ fast.
4. nvt of $4x10^{19}$ slow at 540 F in flowing water.
5. nvt of $5x10^{19}$ slow and $4x10^{19}$ fast in cooling water at 70–140 F.
6. nvt of $1x10^{19}$ slow and $5x10^{19}$ fast (estimated).

[a] *Flat specimens.*
[b] *Subsize round specimens.*
[c] *Notched specimens.*
[d] *Unnotched specimens.*

Table 5—Effect of Irradiation on Impact Properties of Boiler Steels

ASME Type Material	Exposure Conditions		Change in Transition Temp., F	Change in Max. Energy, %
	Flux, nvt	Temp., F		
SA-212	8×10^{19} fast 9×10^{19} slow	125	+115 to +170	−23 to −29
SA-70	7.5×10^{19} slow	125	+125	−41
SA-212	2×10^{18} fast 8×10^{18} slow	580	+45	−5
SA-212	2×10^{18} fast 8×10^{18} slow	425	+35	−7
Aluminum-killed 0.34 Carbon Steel	2×10^{18} fast 8×10^{18} slow	425	+20	−4
Aluminum-killed 0.34 Carbon Steel	2×10^{18} fast 8×10^{18} slow	390	+20	−2
Aluminum-killed 0.34 Carbon Steel	2×10^{18} fast 8×10^{18} slow	350	+20	−4

pronounced on hardened metals than on metals in the annealed condition. An accompanying chart, which includes plain-carbon steels and zirconium, compares the effect of various irradiation dosages on these groups of metals.

Impact Strength

Since tests were conducted on the subsize specimens shown, little significance is attached to absolute values of energy or of transition temperatures. Rather, comparisons are confined to unirradiated versus irradiated results. The results in Table 5 are in two groups. The first group are those exposed to relatively high integrated fluxes at relatively low temperatures. The second group are those exposed to relatively low integrated fluxes at relatively high temperatures.

While the ASME types SA-70 and SA-212 boiler steels have similar chemical composition the effects of irradiation are similar: an increase in ductile-brittle transition temperature and a decrease, under ductile conditions, in maximum-energy fracture values.

The transition temperature is significantly raised 115 to 170 F higher when the exposure is to high flux and low temperature, and raised only 35 to 45 F when the exposure is to low flux and high temperature. The energy values are decreased more by high flux-low temperature than by low-flux high temperature. Irradiation effects are not as pronounced (20 F increase) on aluminum-killed materials, since the finer-grain size imparted by the added aluminum tends to promote lower transition temperatures.

Judging from the data currently available, the effects of irradiation on the impact strengths of materials are cause for interest to the designer and metallurgist. The changes must be allowed for in design and in material selection and treatment.

Fatigue Strength

No significant changes due to irradiation are evident from the comparison of fatigue curves of stainless steel type 304, of Grade I crystalbar zirconium, and of a double-melted 2½% tin-zirconium alloy exposed at 140 and 540 F.

Effect of Radiation on Physical Properties

Table 6—Effect of Irradiation on Density of Structural Materials

Material Type	Average Density, gm/cc		Average Change, %
	Before Irradiation	Difference, After Irradiation	
STAINLESS STEELS			
316	7.995	−0.005±0.002	−0.06
347	7.938	−0.007±0.002	−0.09
347+Ta	7.942	−0.003±0.001	−0.04
410	7.675	−0.004±0.001	−0.05
NICKEL-BASE ALLOYS			
Nickel-A	8.894	−0.006±0.002	−0.07
Monel	8.836	−0.004±0.003	−0.05
COBALT-BASE ALLOYS			
Stellite 3	8.550	+0.005±0.002	+0.06
Stellite 6	8.330	+0.009±0.001	+0.11
CARBON STEEL			
SA-212	7.850	0±0.003	0

Radiation Exposure: nvt of 2×10^{20} slow and 3.5×10^{19} fast at 70–140 F.

Density and Dimensional Stability

Most density changes on common materials fall within the ± 0.05% limit of experimental accuracy. However, as shown in Table 6, stainless steels and nickel-base alloys have been shown to decrease 0.06%, and cobalt-base alloys have been shown to increase 0.09% in density. No significant changes are noted for plain-carbon steels irradiated simultaneously.

Large density changes have been confined to sintered materials. Tungsten carbides and tantalum carbides with cobalt binder show density decreases from 0.3 to 0.6% without any correlation to the slight dimensional changes. Titanium carbide with nickel binder increases in length and decreases in width by small percentages while the density decreases from 0.3 to 0.6%.

Tantalum and tungsten densities decrease 0.10 to 0.15%, and a tantalum tungsten alloy decreases in density from 0.20 to 0.25%.

Magnetic Susceptibility

Irradiation probably causes some phase transformation from austenitic to ferritic iron, as indicated by magnetic susceptibility changes shown in Tables 7 and 8. However, it is felt that the amount transformed is not of significant magnitude to show an appreciable increase in corrosion susceptibility of the more common stainless steel types.

The austenitic stainless steels are only slightly magnetic before irradiation and the increases are relatively large. Nevertheless, the total magnetism attained is still relatively insignificant. Type 309 (25% CR-12% Ni) material is less affected since the austenite in this type is inherently more stable than in the 18:8 types.

The ferritic and precipitation-hardening alloys display higher initial values with relatively smaller increases due to irradiation. Type 446 stainless steel shows a decrease in magnetic susceptibility after irradiation.

Electrical Resistivity

Electrical resistivity changes on stainless steels and nickel-base alloys are low when exposed at 500 F. As shown in Table 9, the changes are not greater than 5%. Electrical resistivity measurements remain fairly constant for tantalum and a tantalum-tungsten alloy, but increase 40% for tungsten.

Impact testing machine adapted for radioactive specimen testing. Note remotely-controlled mechanisms for raising pendulum, for arresting pendulum swing after test, and hydraulic jack for raising machine off floor so that it may be wheeled as a unit in and out of the "caves".

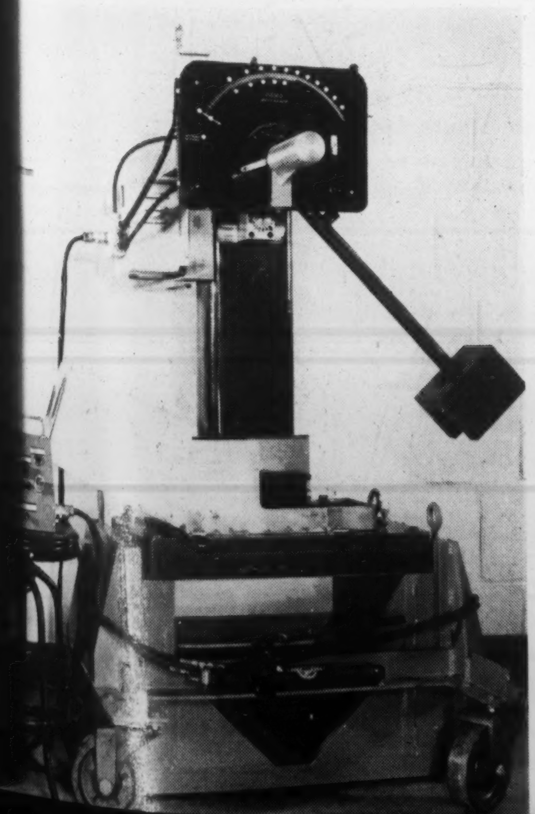


Table 7—Effect of Irradiation on the Magnetic Susceptibility (Guoy Method) of Stainless Steels

Material Type	Magnetic Susceptibility(1) 10⁻⁶ cgs Before Irradiation	Magnetic Susceptibility(1) 10⁻⁶ cgs After Irradiation	Magnetic Susceptibility(1) Increase, %
304	31.98	202.47	533
304	33.74	211.83	528
309	31.65	88.30	179
316	29.17	228.74	684
347	31.74	210.28	563

Radiation Exposure: Calculated nvt of $1x10^{19}$ slow.
(1) Determined by the ratio of the volume susceptibility to the density.

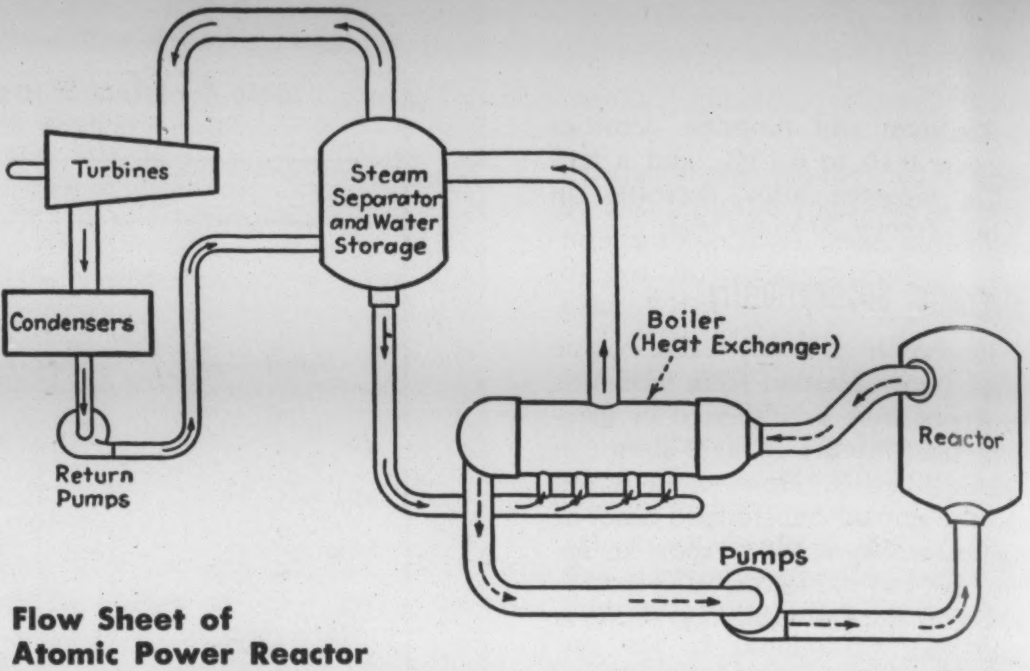
Table 8—Effect of Irradiation on the Magnetic Susceptibility (Magne-Gage Method) of Stainless Steels

Material and Treatment	Aminco-Brenner Magne-Gage Readings: Magnet(1) Number	Before	After	Relative Increase, %
329 Annealed	4	3	3	0
347 Cb-Ta Annealed	4	2	4	100
347 Cb-Ta Shot Peened	4	2	9	350
431 Hardened	1	100	114	14
431 Annealed	1	105	125	20
442 Annealed	1	117	124	5
446 Hardened	1	103	85	−18
Armco 17-4 PH Hardened	1	110	114	4
Armco 17-7 PH Hardened	1	100	111	11
Armco 17-7 PH Malcomized	1	47	62	30
U.S.S. Type "W", Hardened	1	110	121	10

Radiation Exposure: Calculated nvt of $3x10^{19}$ slow in flowing water at 540 F.
Specimens ⅜-in. dia by ¾-in. long.
(1) Magnet numbers refer to field force, but do not refer to any specific value. For example, Number 4 is stronger than 1, but no correlation is available.

Table 9—Effect of Radiation on Electrical Resistivity

Material	Electrical Resistivity, Micro-Ohm-Cm Before Irradiation	Electrical Resistivity, Micro-Ohm-Cm After Irradiation
STAINLESS STEELS		
304	80.2 at 28.0C	80.4 at 27.8C
309	79.9 at 27.5C	82.01 at 27.0C
316	77.0 at 28.4C	78.01 at 28.4C
347	75.5 at 26.2C	75.94 at 27.3C
NICKEL-BASE ALLOYS		
Nickel-A	9.8 at 27.0C	9.63 at 27.2C
Hastelloy-C	126.5 at 26.2C	133.80 at 27.8C



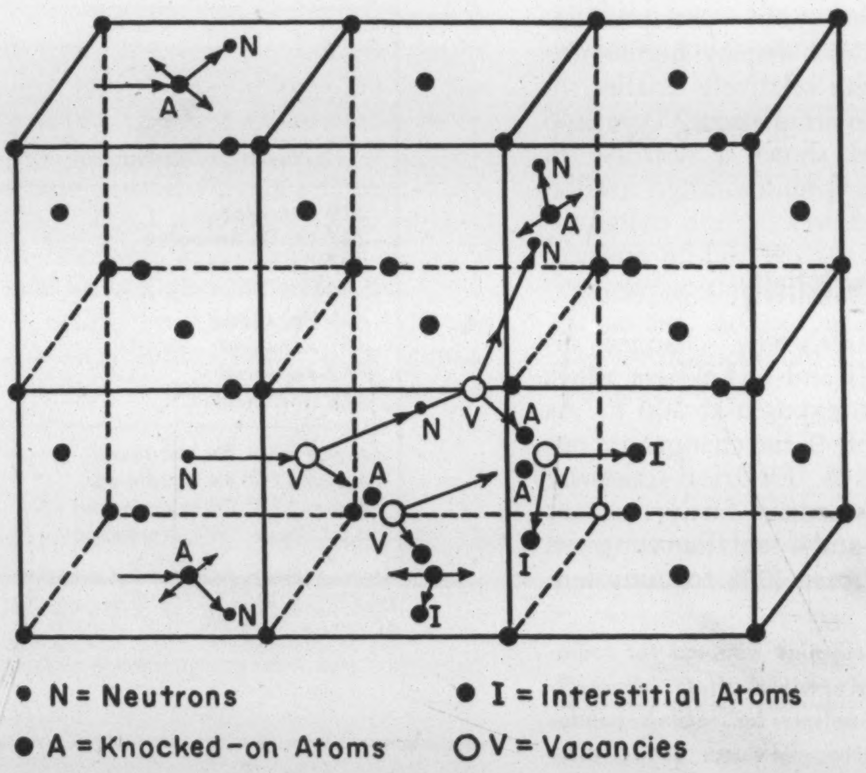
Flow Sheet of Atomic Power Reactor

A fluid coolant, which can withstand high temperatures and radioactive bombardment, is pumped through the reactor. From the reactor, the medium goes to the heat exchanger and back again, after passing through auxiliary systems. This method of producing power requires heavy shielding weighing several hundreds of tons to prevent radiation hazards. The greatest weight of any reactor lies in the shielding. A shield having the highest efficiency per unit volume becomes the lightest shield. To date, the shielding problem has been an important factor in delaying small atomic-power installations for locomotives and airplanes.

How Irradiation Damages Materials (Simplified Theory)

The physical, mechanical and chemical properties of materials are affected by the structure of the atoms and their relation to each other. Each atom has a close-packed nucleus compound of protons and neutrons. This nucleus is surrounded by shells of electrons traveling in orbital fashion similar to planetary travel around the sun. Inside the atom there are powerful repelling forces between like charges. There are also even more powerful forces of attraction. Clues to the properties of materials can be gained from a knowledge of these forces within the atoms.

The principal radiations resulting from the fission process in chain reactors are alpha and beta particles, gamma rays, neutrons and fission fragments. The alpha particle is identical to the nucleus of the helium atom. A beta particle is nothing more than an electron traveling at high velocity, while gamma rays are similar to very powerful x-rays. Neutrons are uncharged particles which have been dislodged from the nucleus of atoms. Fission fragments result from the splitting apart of a nucleus of the heaviest atoms (uranium, etc.) into two more-or-less equal parts.



This model shows in simplified form how radiation damage occurs. The lattice work represents the relative atomic structure of an element showing the various atoms in position. Neutrons (N) are shown knocking out atoms (A) and causing a dislocation of that atom from its normal lattice position. This interaction in turn has left a lattice vacancy where the atom was dislocated. The neutron may continue on its path and cause more vacancies in the same manner. The knocked-on-atom may, in turn knock out other atoms or be impregnated into another lattice position by being forced or wedged between other atoms and become an interstitial atom (I).

These radiations interact with the atoms of an exposed material by several processes. The most important type of inter-action is the collision of a neutron with an atom, causing a dislocation of that atom from its normal lattice position. The struck atom may cause a subsequent or secondary dislocation by knocking other atoms out of the lattice. Another fairly important inter-action is the transmutation or conversion of the atomic nucleus itself to form a different element. Finally, a large part of the original energy of the incident radiation goes into the exposed material as heat.

The rate and extent of alteration of properties of different materials under particle bombardment will depend on the number of primary and secondary dislocations, and on the number of atoms that do not return to normal positions in the lattice. The number and magnitude of these dislocations, in turn, are a function of the intensity and time of irradiation exposure until a structure saturated with dislocations or transformations emerges. After saturation, irradiation has negligible effect.

Effects of Radiation on Nonmetallics

Elastomers—The known effect of irradiation on natural and synthetic rubbers tested has been confined to weight losses; there has been no apparent effects on elasticity or color. However, these results are from samples irradiated for only short periods. Data on the effect of extended exposures are not available at this time.

Electrical Insulators — Specimens of alumina, zircon, beryllia, siliminite, mica, magnesia and quartz have been irradiated. There is an indication that some color changes occur along with a decrease in electrical resistivity. There is some indication that the phenomena are confined to the surface. Of particular significance is the fact that post-irradiation anneals have restored much of the original color and electrical resistivity to many of the materials. In most cases, the dielectric strength decreases. Dimensional changes are within the accuracy of measurement.

Plastics — Plastics can be used under irradiation for applications where the total irradiation is limited. In high-intensity radiation zones the service lifetime of plastics is sacrificed, while under low-intensity radiation the service is prolonged. Properties show changes due to a degradation of the molecular structure under irradiation until the plastic crumbles. Some plastic materials evolve gaseous-

Test Procedures

Since development work necessitates radiation exposures that simulate operating conditions, it is not always possible to determine the effects of irradiation entirely by standard tests. Sizes and numbers of specimens are restricted by reactor-test space and time requirements. In-pile measurements and post-irradiation measurements on radioactive specimens are difficult to perform and thus compound the difficulty of test procedures.

Types and dimensions of specimens are shown in accompanying figures. Identical unirradiated specimens, held under similar conditions of ambient temperature and surrounding medium, are tested at the same time and conditions as the irradiated specimens. This procedure permits a separation of variables within the limits of the experiment.

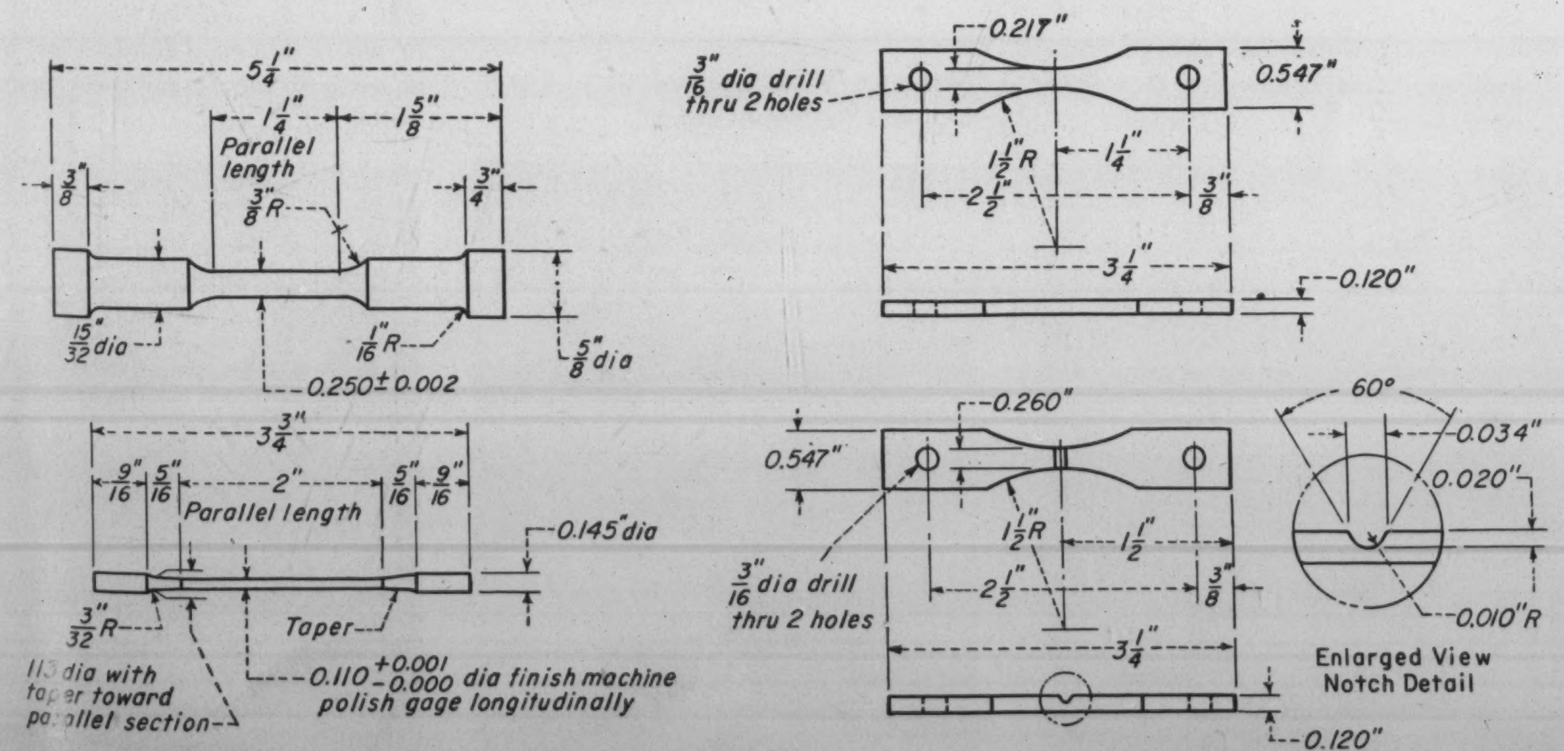
Standard mechanical and physical-testing equipment have been adapted for restricted-space use and remote-control manipulation. Requirements are guided by residual radiations from the irradiated specimens.

In order to determine the effect of radiation intensities, the exposures are measured in nvt, where:

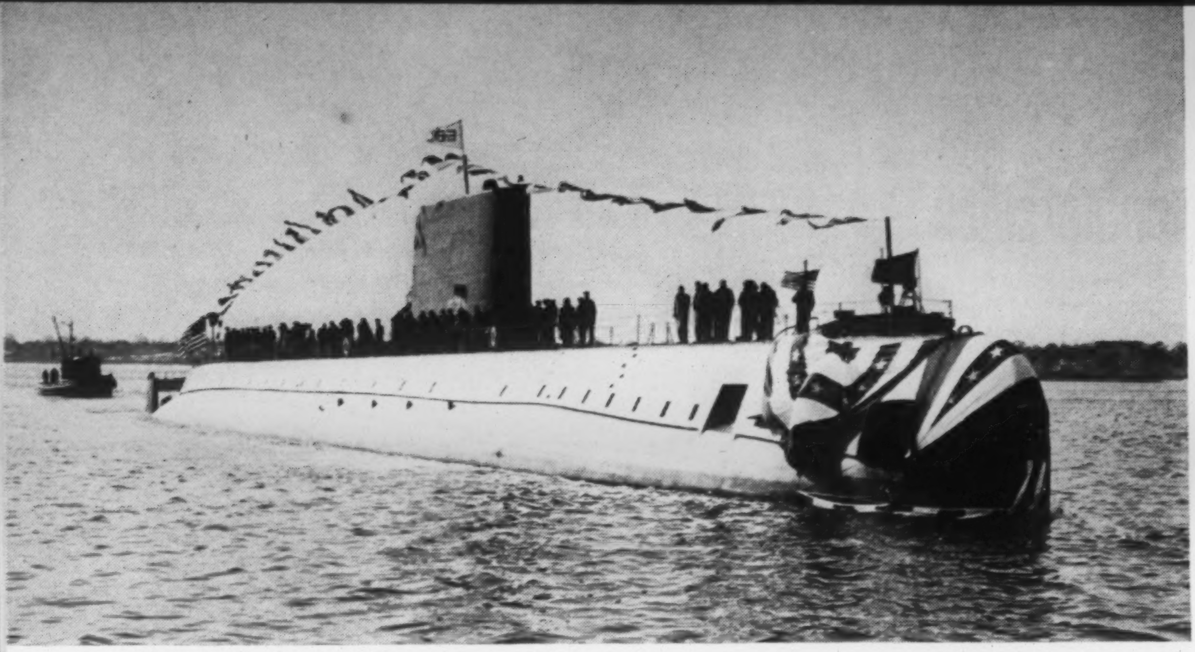
n = neutrons per unit volume in incident beam
v = neutron velocity
t = exposure time

The quantity nvt is known as the "integrated flux" since it is the number of neutrons incident per unit area for the total time that the specimen is exposed.

Both slow and fast integrated flux energies were used for most tests. Slow neutrons have energies of approximately 1/40 electron volt. The fast neutrons have energies at least greater than one million electron volts or 10^6 times that of the slow neutrons. The range of neutron energies is generally considered from 10^{-3} to 10^7 electron volts and the range of sizes varies from 10^{-8} to 10^{-12} cm. Successive elastic collisions will continue a process of losing a fraction of the energy per collision of the neutron, the loss depending on the mass of the struck nucleus. The loss is such that a one million electron volt fast neutron becomes a 0.025 electron volt slow, or thermal, neutron after about 24 collisions with hydrogen nuclei.



Types of test specimens used for studying effects of irradiation. Left, tensile specimens. Right, unnotched and notched fatigue-test specimens.



The U.S.S. Nautilus, first atomic energy powered submarine. Many materials problems were encountered in its design. *(General Dynamics Corp.)*

decomposition products, and some absorb oxygen or water vapor. Various types blister and swell, some deteriorate and chip, while others merely shrink. As a rule, there are no pronounced changes in volume resistivity, dielectric strength or arc resistance until the mechanical properties deteriorate completely.

Oils—In order to serve the purpose of an efficient lubricant the viscosity of an oil must remain constant at the level selected for the job. Tests to date on lubricating oils indicate that they are limited to use in protected spaces. Some oils dissociate

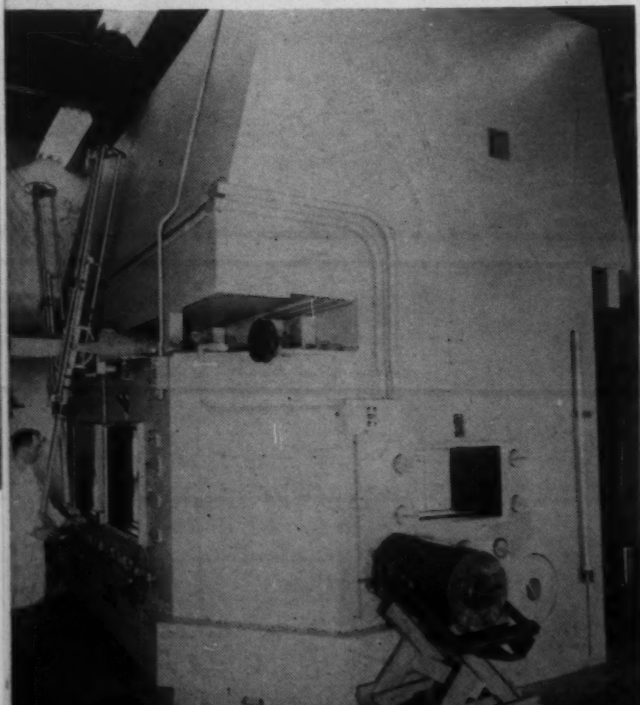
Testing for Radiation Damage

The interior of a high-powered reactor during operation is intensely radioactive. Therefore, chemical, mechanical and physical tests on radioactive materials are carried out in "hot caves" using "master-slave" manipulators which reproduce the seven human motions employed in grasping, lifting, moving and turning objects. By manipulating handles located outside the cave, the operator can cause duplicate motions to take place beyond the wall. The cave wall is concrete, approximately 3 ft thick, and has special viewing windows which have good optical-transmission properties. The windows are either liquid-filled glass tanks or laminated plate-glass sections which offer protection plus good visibility.

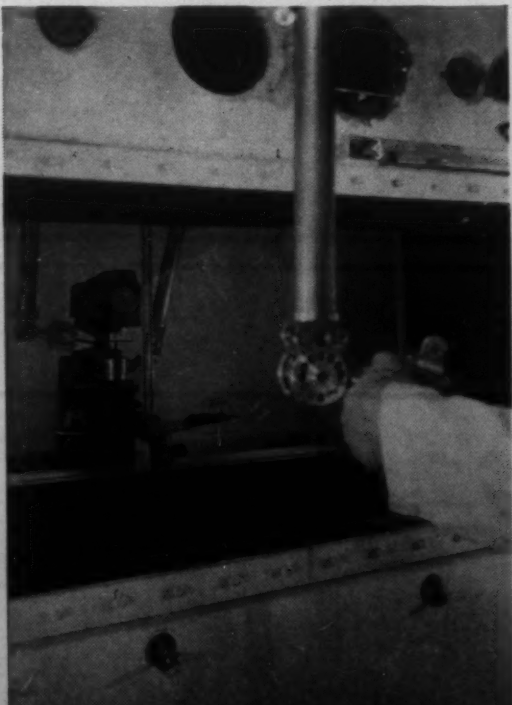
The caves are also equipped to determine the effect of irradiation on the mechanical and physical properties of engineering materials. The equipment includes that necessary for tensile, fatigue, impact, compression, bend, tear and creep tests. Also available is equipment for density, dimensional-stability, electrical-resistivity, magnetic-permeability, corrosion and spalling resistance and notch-sensitivity tests; spring constants, relaxation and stiffness; and chemical analysis.

Argonne engineers have also developed the use of stereoscopic or three-dimensional television for experiments where radiation is so intense that the research worker must be at a considerable distance from the materials being handled. The camera uses twin transmitters with tubes at slight angles. This permits the separation of the right-eye and the left-eye images. A clear picture in three dimensions is visible to an operator or observer using properly polarized spectacles.

With his hands on master-slave manipulators and looking through a 3-ft-thick window, an Argonne engineer makes a precise and complicated measurement in a radioactive specimen.



Performing a hardness test on irradiated specimens by remote control.



With special spectacles the operator sees TV picture in three dimensions and is able to perform delicate operation via remote control.

into gases and liquids, while others dissociate into gases and gels. The major physical property changes in oils during radiation include changes in color, viscosity and index of refraction. In all cases the changes in the viscosity and index of refraction are proportional to the duration and intensity of bombardment. Two questions are yet to be explained about the effect of irradiation on oils: 1) what the effects of oxygen and other gases are in radiation damage; and 2) why some organic materials appear more resistant than others.

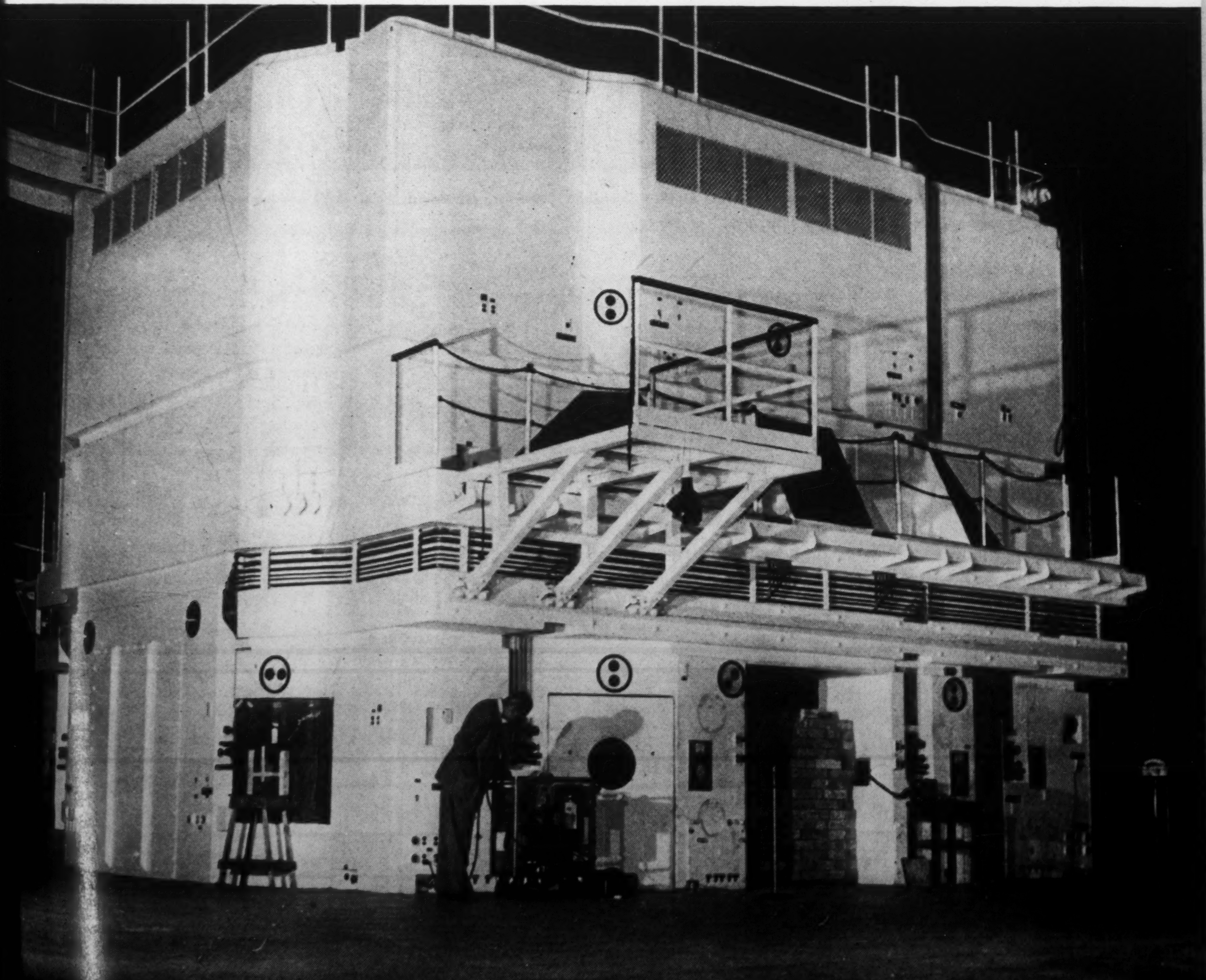
Table 10—Neutron Absorption by Structural Materials

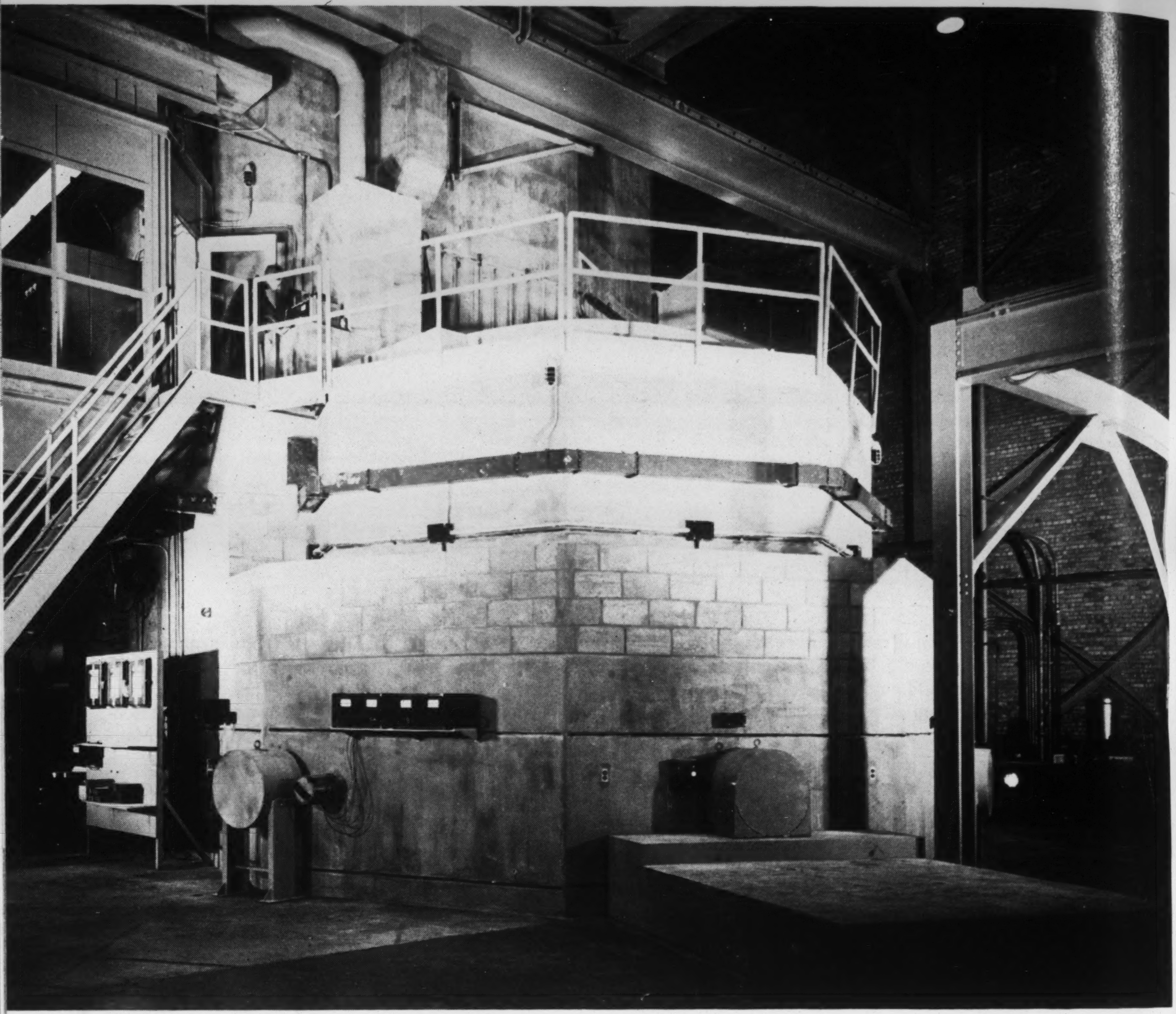
Material	Relative Neutron Absorption, per cm^3 x 10^3	Relative Neutron Absorption for Pipes of Equal Strength (20C)	Melting Point, F
MAGNESIUM	3.5	10	1200
ALUMINUM	13	102	1230
STAINLESS STEEL	226	234	2730
ZIRCONIUM	12.6	16	3330

Neutron Absorption

Table 10 lists some structural materials which have been or could be used in reactors. Mechanical and physical properties of contemplated structural materials are important, but we must also consider its use and position in the reactor. In the second column of the Table, relative neutron absorptions are listed. This value is not enough since the strength of the structural member will determine how much is to be used. Therefore, the third column lists the relative neutron absorption for pipes of equal strength and identical internal diameters. Under this light, great superiority of zirconium is immediately apparent. Magnesium and aluminum, although much

A materials testing reactor in operation irradiating materials considered for use in improved reactors.





Interior of experimental breeder reactor at AEC station in Idaho. Reactor is doing dual job of breeding fissionable material and creating heat that can be converted into electrical energy.

better than stainless steel, are ruled out for a power reactor because of corrosion difficulties and low melting point.

Steel and zirconium are the likely prospects for the contruction of pipes and supports for the internal parts of an elevated-temperature reactor. Since steel imposes a severe penalty on the reactor operation because of its large parasitic capture of neutrons, it is not surprising that the AEC has expended a large amount of effort in obtaining and learning how to use purified zirconium metal. Unfortunately, zirconium occurs with hafnium from which it can be separated only with extraordinary difficulty. The natural zirconium-hafnium mixture is no improvement over steel with regard to neutron absorption.

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Materials Engineering File Facts

MATERIALS & METHODS
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Number 280

Comparative Electrical Properties of Some Metals

Material	Alloy	Density Lb/Cu In.	Yield Str Psi	Equal Volume Elect Cond % I.A.C.S.[1]	Equal Weight Elect Cond % I.A.C.S.[1]	Elec Res (at 68 F) Microhm Cm
Copper Annealed		0.322	10,000	100.0	100.0	1.71
High Brass	65Cu-35Zn	0.306	18,000	26.0	27.3	6.2
Die Cast Zinc		0.240	—[2]	27.0	36.0	6.16
Gray Cast Iron		0.256	—[2]	2.0	2.5	74.62
Malleable Iron		0.265	33,000	6.0	7.2	32.0
Cast Carbon Steel		0.284	40,000	11.0	12.5	14.2
Structural Steel		0.283	45,000	12.0	13.6	14.3
Aluminum-Wrought	2S	0.098	5000	61.0	200.4	2.92
	3S-½H	0.099	18,000	41.0	143.5	4.20
	52S-½H	0.097	29,000	35.0	115.1	4.93
	24S-T	0.100	46,000	30.0	96.6	5.75
Aluminum-Cast	43	0.097	13,000	37.0	122.8	4.66
	195-T6	0.101	33,000	37.0	118.0	4.66
	356-T6	0.097	24,000	39.0	129.6	4.42
	220-T4	0.093	25,000	21.0	72.7	8.21
Magnesium-Wrought	Comm. Pure	0.063	—[2]	38.0	194.2	4.46
	M1	0.064	18,000	34.0	171.0	5.0
	AZ31X	0.064	22,000	17.0	85.5	10.0
	AZ80X	0.066	32,000	11.0	53.7	16.2
Magnesium-Cast	A10	0.066	13,000	10.0	48.8	15.0
	AZ63	0.066	14,000	15.0	73.2	11.5
	AZ92	0.066	14,000	12.0	57.6	14.0

[1] *International Annealed Copper Standard.*

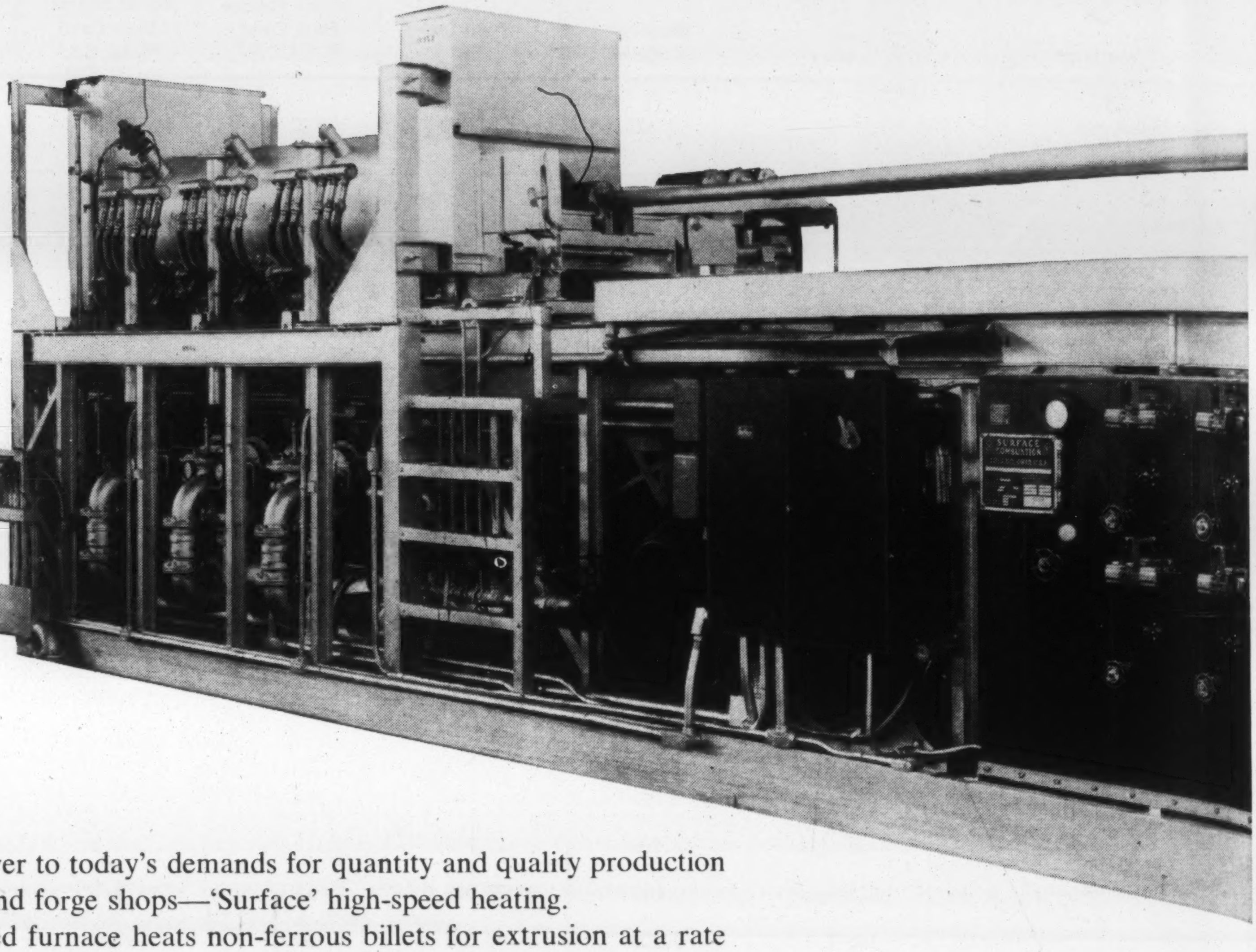
[2] *No definite yield point obtainable.*

Courtesy of "The Magazine of Magnesium" published by Brooks & Perkins, Inc.

◄ For more information, Circle No. 469

MORE TONNAGE/HR./SQ.FT.

'Surface' high-speed furnace heats non-ferrous billets for extrusion at 19,250 lbs/hr.



Here's an answer to today's demands for quantity and quality production in heat treat and forge shops—'Surface' high-speed heating.

This gas-fired furnace heats non-ferrous billets for extrusion at a rate of 19,250 lbs/hr. It consists of a high-thermal head, barrel-type heating chamber operating on a precise, automatic time cycle.

The user reports these advantages:

1. Finer grain structure.
2. Reduced number of billets in heating chamber.
3. Minimum delay to change alloy being heated.
4. Clean billets with no special atmosphere.
5. Reduced rejects.
6. Accurate control and measurement of billet temperatures.

Ideal for non-ferrous shops, 'Surface' high-speed furnaces have proved their flexibility in many ferrous heating applications. They are being used for such processes as forging, upsetting, stress relieving, with better results that pay off in more and better production.

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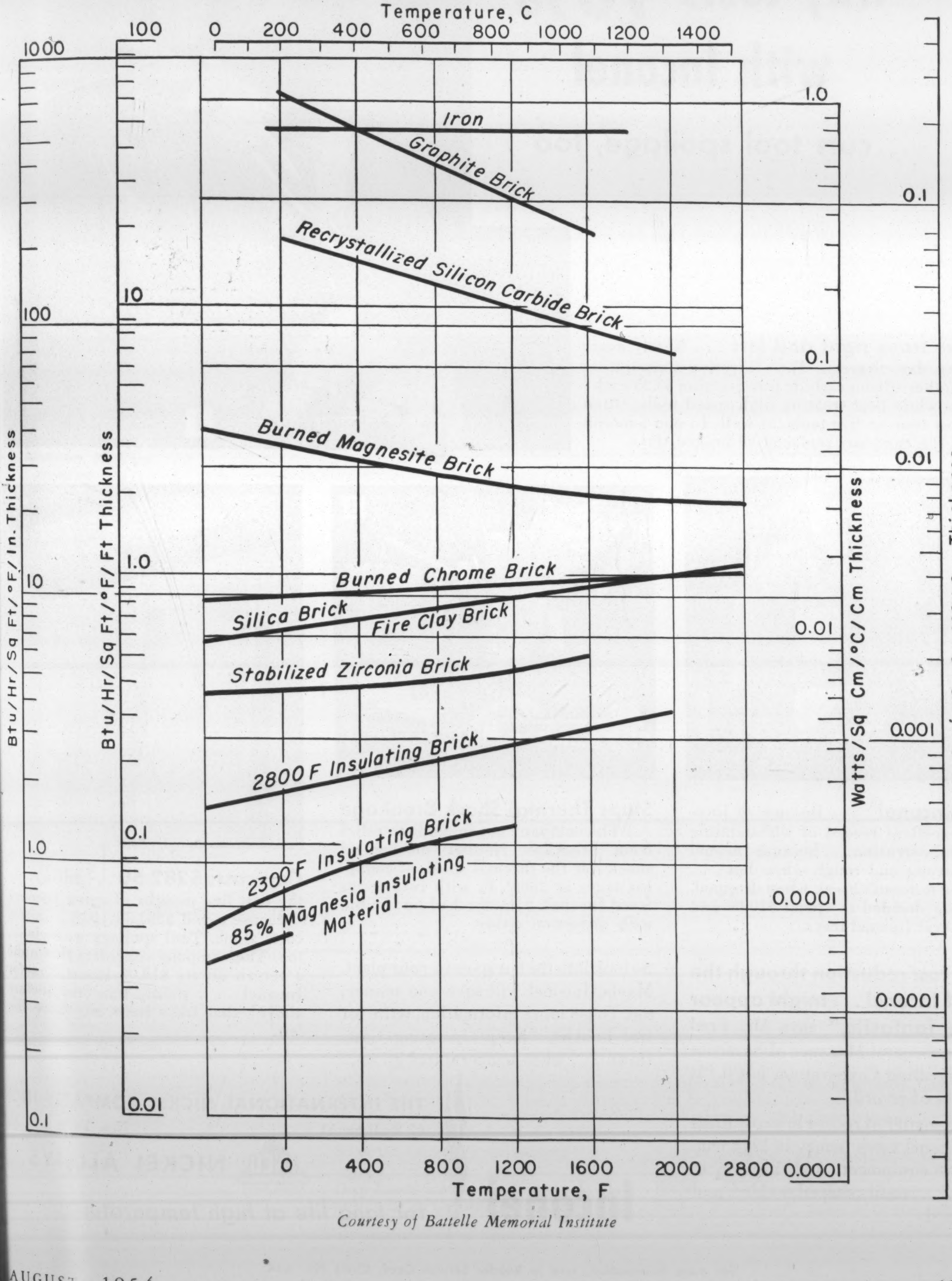
For more information, turn to Reader Service Card, Circle No. 463

MATERIALS & METHODS
August • 1954
Number 281

Thermal Conductivity Conversion Charts

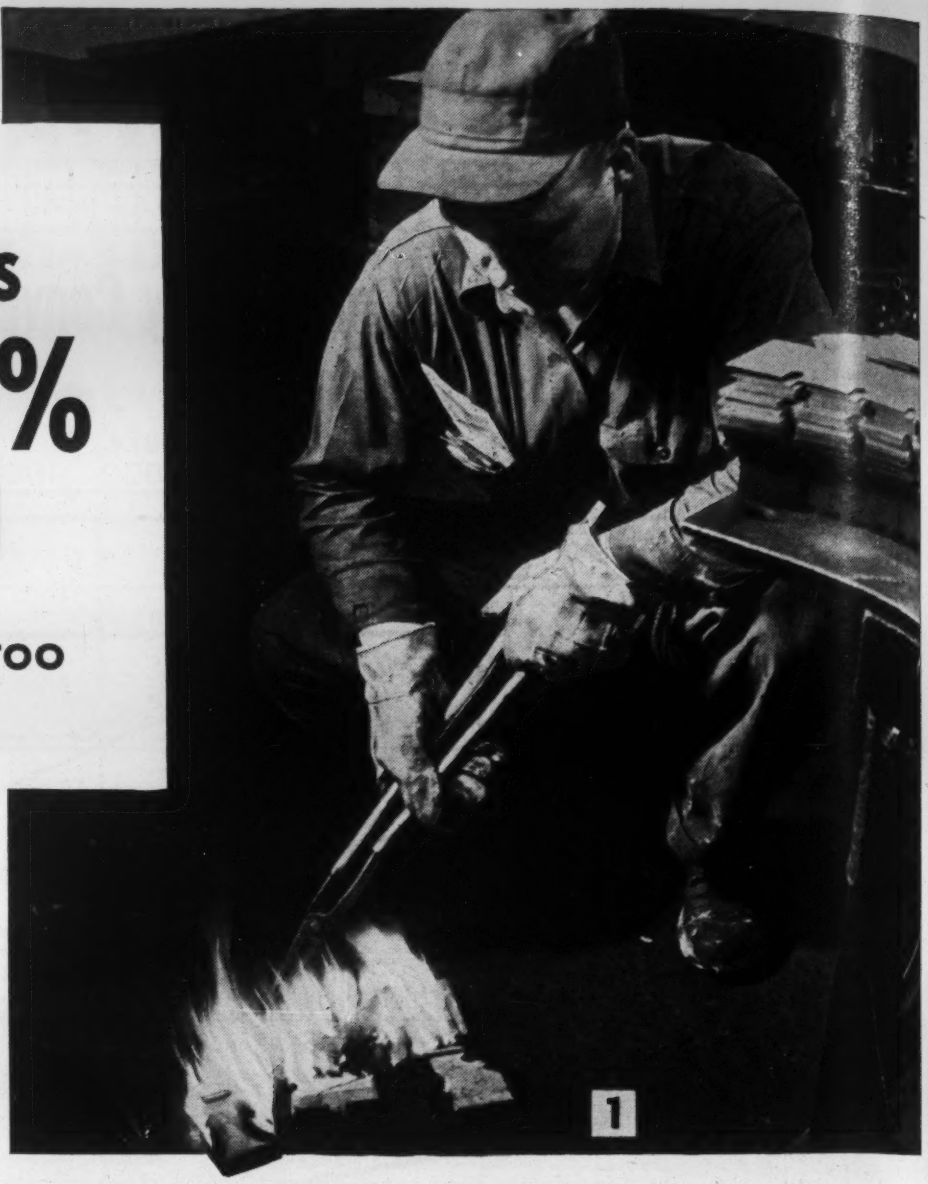
Mean thermal conductivity values for common refractory materials are presented in the four most prevalent units of measurement.



Courtesy of Battelle Memorial Institute

Syracuse cuts tray costs 96% with Inconel

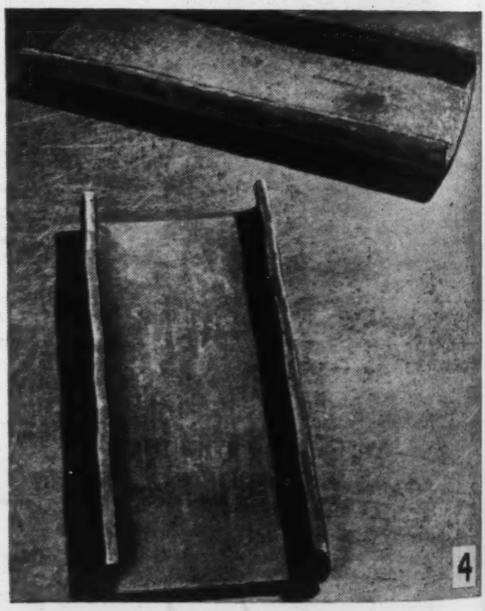
...cuts tool spoilage, too


1

Breaks trays right and left . . . Nearly every working day, Syracuse Heat Treating Corporation had another silicon carbide tray (costing $3.25 each) broken while heat treating high speed tools. Often they lost four or five tools, as well. In one 5-month period the company replaced 90 broken trays.

2

3


4

Tries Inconel® . . . Because of Inconel's excellent record of withstanding heat and corrosion . . . because Inconel stays strong and tough when hot . . . because it doesn't break when dropped. Syracuse decided to spend $10.00 and try several Inconel trays.

"The cost reduction through the use of Inconel . . . might appear to be fantastic," says Mr. Fred Hunter, General Manager of Syracuse Heat Treating Corporation, but it "is a matter of record."

It's a matter of record in many firms that Inconel saves money in high temperature equipment. And, it's easy to handle . . . readily shaped, welded, and machined.

Stops Thermal Shock Breakage . . . The company got immediate relief from breakage. Neither mechanical shock nor the thermal shock of clamping trays at 2300° F. with cold tongs fazed Inconel. Syracuse had no trouble with distortion either.

So look into the hot spots in your plant. Maybe Inconel will save you money, too. To get more information, write for free booklet, "Keep Operating Costs Down . . . when temperatures go up."

Cuts costs $282.50 . . . plus... In the first five months of using Inconel, Syracuse saved $282.50 (96%) in tray costs alone. Tool spoilage went down, too. The company considers that quite a return on its $10.00 investment for Inconel . . . points out (see picture above) that trays have lots more life left.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO TRADE MARK **NICKEL ALLOYS**

Inconel *for long life at high temperatures*

For more information, turn to Reader Service Card, Circle No. 434

Materials Engineering File Facts

MATERIALS & METHODS
August • 1954
Number 282

Materials Data Sheet

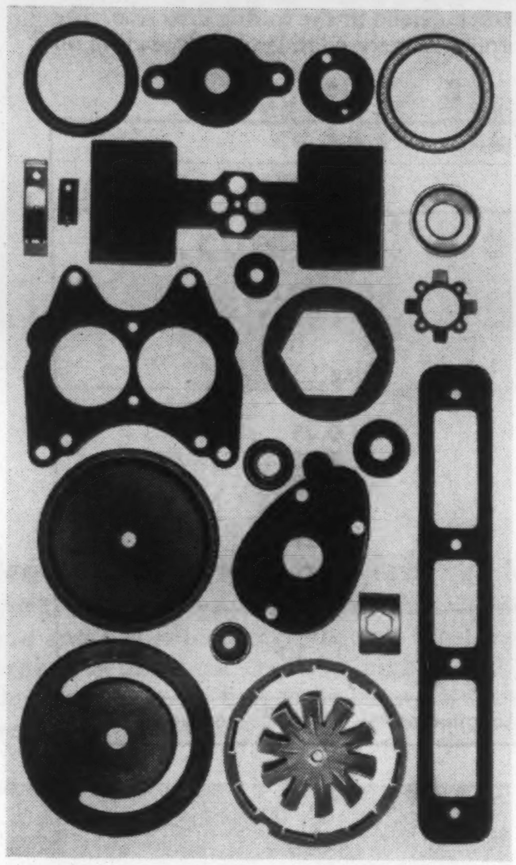
Ingot Iron and Wrought Iron

Ingot iron is the purest form of iron available on a tonnage basis. Wrought iron may be considered as an ingot iron into which varying quantities of slag have been introduced intentionally. This slag is distributed throughout the iron in fibers which extend in the rolling direction. The presence of these fibers imparts a tough fibrous structure to the metal and as a result the mechanical properties vary considerably depending on the direction of testing.

Type	Typical Properties		
	Ingot Iron	Wrought Iron	
COMPOSITION—%	C <0.02	C 0.02	
	Mn <0.02	Mn 0.03	
	Si tr	Si 0.15	
	P 0.005	P 0.12	
	S 0.02	S 0.02	
		Slag 3.0	
PHYSICAL PROPERTIES			
Density, Lb/Cu In.	0.28	0.25	
Melting Point, F	2794	2750	
Thermal Cond, Btu/Hr/Sq Ft/Ft/F, at 212 F	38	36	
Coef of Exp per F: 68-212 F	6.8×10^{-6}	6.7×10^{-6}	
Specific Heat Btu/Lb/F	0.11	0.11	
Elect Res, Microhm-Cm at 68 F:	9.7	—	
Magnetic Properties	Magnetic	Magnetic	
MECHANICAL PROPERTIES			
Mod of Elasticity in Tension, psi	29.8×10^6	29×10^6	
		Longitudinal[a]	Transverse[a]
Tensile Str, 1000 psi:			
Annealed	42	—	—
Hot Rolled	44	47	34
Cold Drawn	73	—	—
Yield Point, 1000 psi:			
Annealed	19	—	—
Hot Rolled	23	24	23
Cold Drawn	69	—	—
Elongation in 2 in., %:			
Annealed	48	—	—
Hot Rolled	47	35	7
Cold Drawn	12	—	—
Reduction of Area, %:			
Annealed	76	—	—
Hot Rolled	75	48	12
Cold Drawn	63	—	—
Hardness, Bhn			
Annealed	69	—	—
Hot Rolled	83	105	105
Cold Drawn	142	—	—
Impact Str, Charpy, Ft-Lb:			
Annealed	19	—	—
Hot Rolled	—	29	11
Cold Drawn	—	—	—
Fatigue Str (End Limit), 1000 psi			
Annealed	26	—	—
Hot Rolled	28	23	19
Cold Drawn	33	—	—
THERMAL TREATMENT			
Annealing Temp, F	1700–1800	1300–1400	
FABRICATING PROPERTIES			
Forging Temp Range, F	—	2100–2200	
Bending Temp Range, F	—	1300–1400	
Machinability Index (B1112 steel = 100)	50	50	
Weldability	Readily joined by resistance, arc, and gas methods		
CORROSION RESISTANCE	Like other ferrous metals with the exception of the stainless steels, these materials generally require protection for extended service under corrosive conditions. In spite of its purity, relative corrosion rates of ingot iron are much the same as those of plain carbon steel. Under atmospheric conditions, wrought iron appears to be somewhat superior to carbon steel. In fresh water the two materials have similar characteristics while there is some dispute over their relative merits in salt water service.		
AVAILABLE FORMS	Sheet and strip, wire, rail sections	Tubular products, plate, sheet, bars, structural shapes, wire, chain	
USES	Deep-drawn parts, enamelling stock, third rails, wire for electrical apparatus, roofing	Oil-well casing, heat exchangers, piping for fresh and salt water, tanks, bolts and nuts, roofing, chemical processing equipment, chains	

NOTE: [a] As rolled.

GOT A PRODUCTION
OR DESIGN PROBLEM?
with
• GASKETS • PACKINGS
• WASHERS • SEALS
• SHIMS
• BUSHINGS • "O" RINGS



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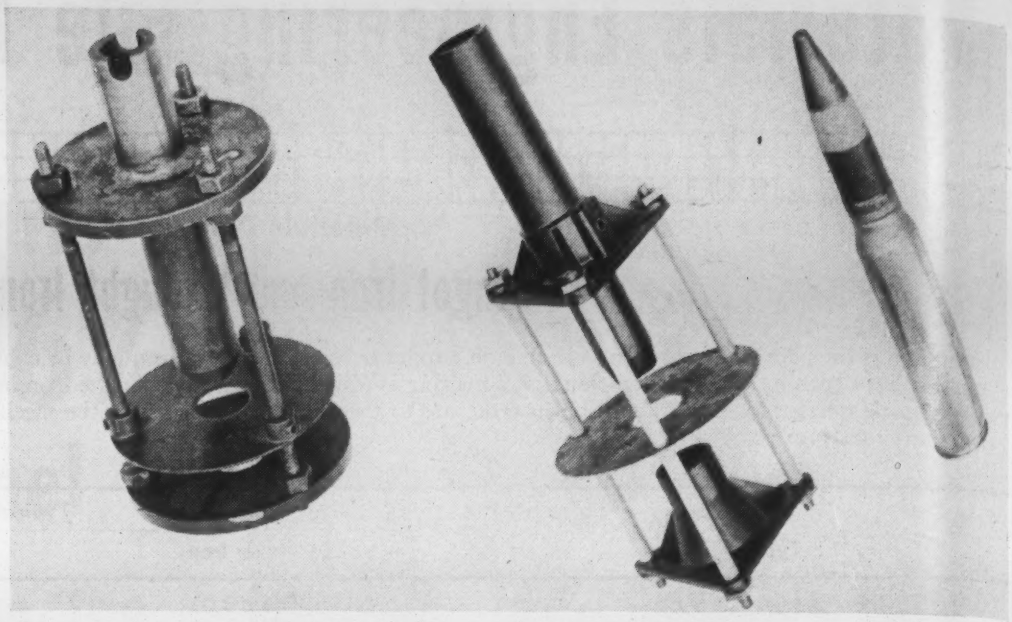


Plastic paint shield (center) used for color-coding projectiles replaces old metal design (left). Wire thread insert is at base of plastics shield.

Wire Screw Thread Inserts

Coiled wire inserts provide one solution to tough problem of producing satisfactory threaded holes in plastics.

by BENJAMIN FRANKLIN, President, Jacobus Plastic Co.

● BY USING A coiled wire insert instead of a solid bushing, stronger and more wear resistant threads can be molded in plastic than was previously possible. This can be done in considerbly less space than required before and at no increase in cost. Although still being performed on a pilot run basis with crude temporary tooling at Jacobus Plastic Co., the new technique has shown promising results.

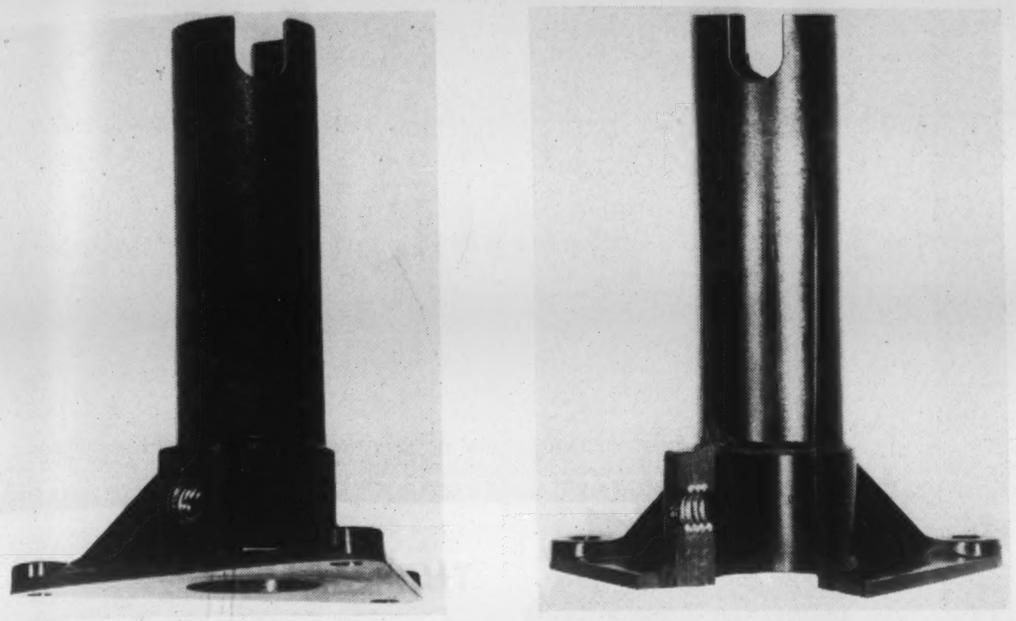
Up to now the molding of thread inserts in plastic imposed several limitations on plastic part design. Bosses in which the inserts were molded had to be relatively large to accommodate a thick-walled solid bushing. Some solid bushings also require extra plastic to cover the end of the bushing and hold it in. Local stresses that weaken the embedment are set up around a solid bushing when the plastic cools after molding. Also, when designed for turn-proof, corrosion-resistant service and accurate placement, solid bushings are expensive to make. They must be knurled or grooved on the outside and carefully drilled and tapped to insure permanent and precise alignment. They must be specially made from stainless steel or bronze if they are expected to resist corrosive conditions.

Even with these limitations, solid bushings are much better than no bushings at all. Threads tapped directly into plastic are usually too weak to support a practical working load, particularly vibration or shock loads, and they will soon wear out if used for frequent screw adjustment.

The inserts presently used are helically wound coils of diamond shaped stainless steel wire. They are embedded in phenolic bottom supports of portable paint shields used for color-coding 20-mm projectiles. The threads they form receive set screws that lock an adjustable center support. In addition to providing strong, wear resistant threads necessary for the frequent adjustment required (changes in setting for every new color code), the threads resist the corrosive effects of the solvent used to clean the shields after each painting.

Wire Insert Advantages

Because of their flexibility, the wire inserts prevent the development of local stresses around the threaded hole in contrast to solid bushings which actually intensify local stresses. The wire inserts require very small bosses because they extend only one thread depth beyond the diameter of the screw. The wall thickness of the phenolic part described is only as



Insert as it appears molded in phenolic base (left). Cut away view showing how deeply wire insert is embedded into molding (right).

Improve Molded Plastic Design

great as the length of the insert because each coil of wire is individually anchored into the plastic.

This individual support of each coil accounts for the reported increase in tensile strength which the wire inserts show over solid bushings. When a screw is pulled up in the thread, elasticity in the plastic permits the flexible inserts to adjust itself slightly until all its coils are in contact with the threads on the screw and are supporting equal shares of the load. Thus, stresses are not concentrated in a relatively small section near the top or at the center of the embedment, as happens with solid bushings. Instead, they are evenly distributed through the entire thickness of the wall.

Wear resistance of the wire threads is superior to the wear resistance of threads in solid bushings because of the differences in hardness, smoothness, and density of the two materials. The wire inserts, manufactured by Heli-Coil Corp., are made from round stainless steel wire rolled to a diamond shape. The resultant surface has a hardness of 48 to 50 Rc, a finish of 4 to 8 microinches. To get a thread quality approaching that of the wire insert, a bushing must be ground and lapped, and the price goes up directly.

Paint Shield Redesigned

The wire thread insert was included as a special feature in the conversion of the paint shield from steel to plastic. The new shield weighs 7 oz as compared with the 41-oz weight of its predecessor — a weight reduction of 82.9%; yet it costs only 17% as much. The shields were redesigned in phenolic because of desirable weight reduction and fire prevention. The drastic weight reduction was necessary because women handle the shields constantly and operator fatique must be kept at a minimum. The use of phenolic for the shields removes a fire hazard present with steel shields which, when inadvertently struck with a metal projectile being inserted, will create a spark that might ignite the highly volatile atmosphere in the paint chamber.

The coiled wire thread inserts are readily adaptable to modern mass production molding techniques. Having a much smaller outside diameter than solid bushings of equal inside diameter, the inserts can more easily be set in the mold. After the part is molded the new thread requires no chasing if the insert is mounted on a threaded mounting stud in the mold.

Fit classification of the molded-in thread can be controlled by grinding the threads on the mounting stud to desired dimensions. The stud dimension should be ground undersize a predetermined amount to compensate for shrinkage when the plastic cools after molding.

Although the present molding set-up is being performed in a makeshift mold on an experimental press, study of the process indicates that a high rate of production is possible. When the single mold hand press operation now being used is converted to a multi-mold, automatic press operation, it is expected that one operator will produce 2000 to 3000 parts per day.

Model KC-2
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Minute (57 Liters).

Model KC-5
(Formerly CVM 3534)
5 Cubic Feet per
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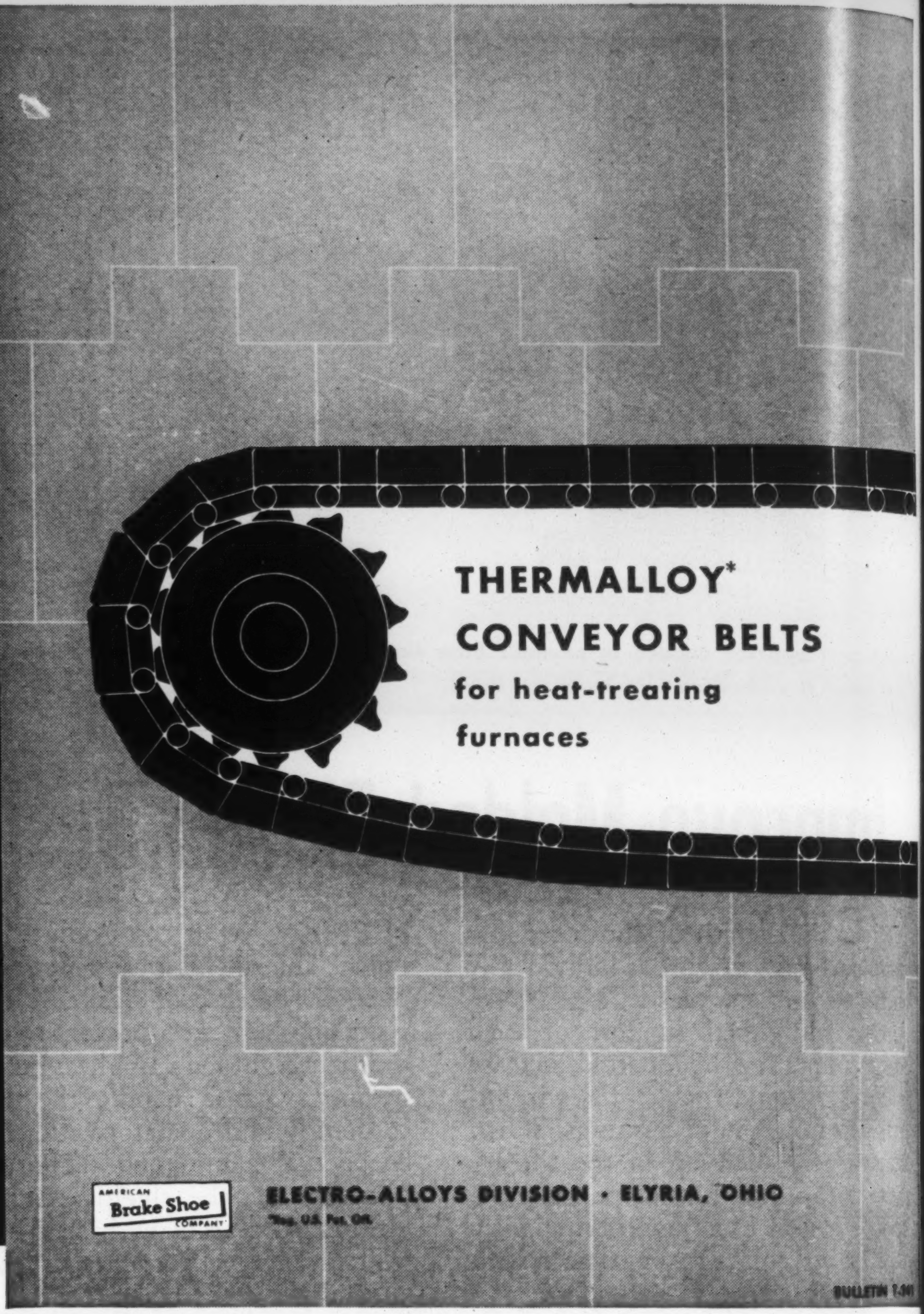

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BULLETIN T-241

See how design know-how and modern foundry practices can produce high alloy conveyor belts that last longer in heat treating operations

In this new bulletin you will see how Electro-Alloys engineers started with certain design theories about high temperature conveyor belts . . . and how these ideas directed the production of heat-resistant Thermalloy castings. You will see the importance attached to precision assembly of these castings into Thermalloy Conveyor Belts.

Finally, you will be interested to know that Electro-Alloys has established unique testing procedures that will give you a good indication of what can be expected from Thermalloy Conveyor Belts in operation. These results are shown in a composite load curve chart in the bulletin. And, Electro-Alloys engineers can apply these results to your installation... so you can get longer service life from Thermalloy Conveyor Belts in your heat treating furnaces.

Start planning now to use Thermalloy Conveyor Belts to lower operating costs. Write for your free copy of Bulletin T-241 . . . Electro-Alloys Division, 5001 Taylor Street, Elyria, Ohio.

AMERICAN Brake Shoe COMPANY

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Elyria, Ohio

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For more information, turn to Reader Service Card, Circle No. 366

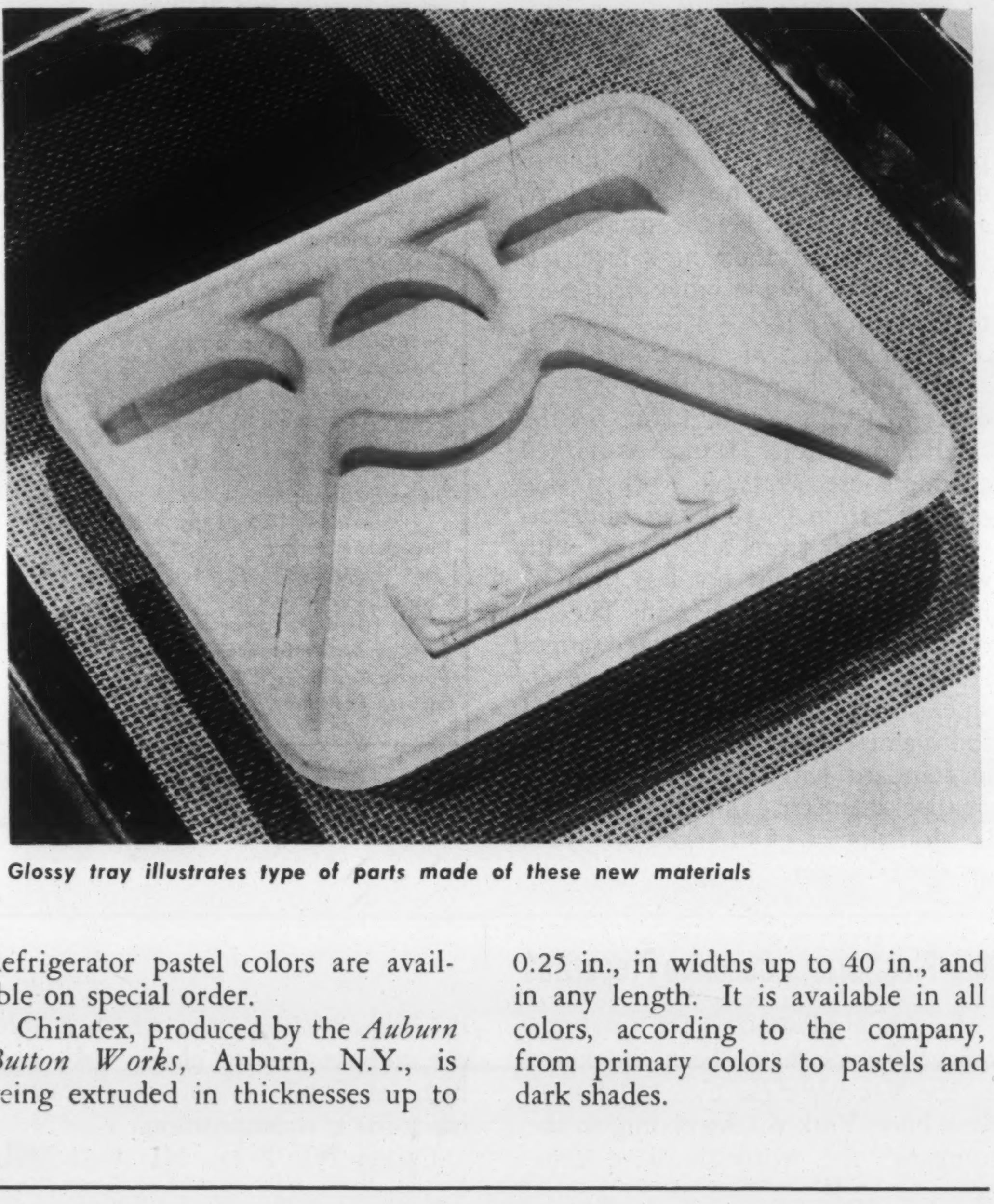
New Materials, Parts and Finishes

. . . and Related Equipment

Polystyrene Sheet Has High Gloss

Two plastics companies have recently developed a method for imparting a porcelain-like glossy finish to rigid polystyrene sheet. The extruded sheet lends itself to vacuum forming, a method requiring only inexpensive dies, thereby allowing economical forming operations with reduced finishing costs. The smooth finish makes it washable and easy to keep clean.

Properties of the materials are said to make them suitable for refrigerator liners and components, product housings, automotive parts, advertising signs and displays and toys and novelty products.



Glossy tray illustrates type of parts made of these new materials

Campco S-300GM, produced by *Campco Div., Chicago Molded Products Corp.*, 2717 N. Normandy Ave., Chicago 35, is available in standard sheet sizes of 39 by 72 in. in thicknesses of 0.080 and 0.100 in. In quantity orders, it can be supplied in 39-in. widths and in any length. Refrigerator pastel colors are available on special order.

Chinatex, produced by the *Auburn Button Works,* Auburn, N.Y., is being extruded in thicknesses up to 0.25 in., in widths up to 40 in., and in any length. It is available in all colors, according to the company, from primary colors to pastels and dark shades.

New Nickel-Molybdenum Pre-alloyed Powder

A new pre-alloyed steel powder which is said to possess a pronounced improvement in toughness and hardenability has been developed by *Vanadium-Alloys Steel Co.,* Latrobe, Pa. Designated Vasco 4650-A, the alloy is similar in analysis to AISI 4650. According to the company, the improvements in the steel powder allow the fabricator to produce high strength powder metal parts by briquetting and sintering without using secondary treatments more elaborate than simple hardening.

The powder is said to have a high green strength and is readily moldable at low pressures. Basically a nickel-molybdenum composition, the grade is available with varying carbon contents. Other improvements claimed by the company are ease of heat treatment, toughness and strength. The powder is expected to find applications in the production of such high production parts as gears where powder metallurgy offers significant savings.

New Materials, Parts and Finishes continued

Lower Cost Fluorocarbon Plastic

Rods, tubing, bars and cylinders of 100% reprocessed polytetrafluoroethylene are now available at what is said to be a substantial reduction in cost over the virgin material. The reprocessed material is also said to retain most of the desirable properties of the virgin polymer, according to the producer, *United States Gasket Co.*, Camden, N. J. (See table of properties below.)

Trademarked Fluoroplast, the material is reprocessed from the same polymer as Teflon, DuPont's fluorocarbon plastic. The fluorocarbons are known for their resistance to chemical attack, their high electrical properties and wide range of service temperatures.

Molded bars of Fluoroplast are available in diameters from 2.25 to 6 in., in lengths up to 12 in. for the smaller diameters. Standard molded cylinders are available with inside diameter from ½ to 19 in. and outside diameter from 2 to 20 in., with wall thicknesses of not less than ½ in. and not more than 2 in. The extruded tubing inside diameter ranges from ¼ to 1½ in., with outside diameter from ⅜ to 2 in. The extruded rod diameters range from ¼ to 2 in. in standard lengths of 6 ft for the smaller diameter, and 2 ft for the larger diameter. Other sizes are available on special order.

Typical Properties of Fluoroplast

Property	ASTM Method	Values
Tensile Strength 73 F, Psi	D-638-49T	1300
Elongation 73 F, %	D-630-49T	50
Flexural Strength 73 F, Psi	D-790-49T	2000
Modulus of Elasticity in Flexure 73 F, Psi	D-790-49T	80,000
Hardness Duro. D Scale	—	50–70
Impact Strength, Izod, Ft Lb/In.		
−70 F	D-256-47T	1
73 F	D-256-47T	3
170 F	D-256-47T	4
Compressive Strength, Psi		
at 1% Def. 73 F	D-695-49T	600
at 1% Offset 73 F	D-695-49T	1300
Deformation under load, %		
122 F 1200 psi 25 hr	D-621-51	2–4
122 F 2000 psi 24 hr	D-621-51	8–10
Heat Distortion Temp 66 psi, F	D-648-45T	225
Chemical Resistance	D-543-43	Inert
Weathering Resistance	—	See above
Water Absorption, %	D-570-42	0.0
Flammability	D-635-44	Non-flammable
Specific Gravity	D-792-48T	2.1–2.3
Dielectric Strength		
—short time. 125 at cps, v/mil	D-149-44	425–450
Dielectric Constant		
60 to 10^8 cps	D-150-47T	2.0
Dissipation Factor		
60, 10^3, 10^6, 10^8 cycles	D-150-47T	<0.0005
Surface Arc Resistance, Sec	D-495-48T	400
Volume Resistivity, Ohm/cm	D-257-49T	7.2×10^{15}
Surface Resistivity, megohms	D-257-49T	3.6×10^6

Values compiled from test data by U. S. Testing Co. and the Electrical Testing Lab.

New Plasticizers Combine Properties

Four new plasticizers for vinyl and other plastics have been marketed by the *National Lead Co.,* 111 Broadway, New York 6. According to the company, the materials have combinations of properties which enable the compounder to obtain with one material certain important characteristics for his composition.

Coded NL F-21, NL F-31, NL F-41 and NL A-54, the so-called Dutch Boy plasticizers are said to be suitable for use in such vinyl plastics goods as raincoats, upholstery, garden hose, wading pools and flooring.

Two New Epoxy Materials

A new high heat distortion temperature epoxy material has been marketed by the *Houghton Laboratories, Inc.,* 322 Bush St., Olean, N.Y. Called Hysol 6000HD, the material is said to have a heat distortion temperature of over 300 F, which is the present maximum range for the epoxy materials.

The plastic is dark transparent amber and is supplied in sheets, rods and tubes. Custom castings will also be made to specifications. The epoxies are known for their high electrical properties, good machinability and low water absorption.

Another new epoxy material developed by the company is a potting compound designated Hysol 6040. Its heat distortion temperature is around 250 F. It is available with the Hardener AN for use in potting resistors, capacitors and other electrical components.

Aluminum, Neoprene Combine in Protective Coating

An aluminum-neoprene coating designed for protection of ferrous metals against atmospheric corrosion, salt spray and fumes has been marketed by the *Chemical Coatings and Engineering Co.,* The Rucker Bldg., Darby, Pa. Called Seaco #342, the coating is designed to combine the chemical and weathering resistance of neoprene with a reflecting and non-fading pigment. The material is self-curing at room temperature.

The applied coating resembles aluminum in appearance and, if desired, the coating can be tinted to give a wide range of metallic colors. The coating is elastic and has low moisture or chemical permeability. Application is by brush, spray or roller; coverage is 170-sq ft per gal per 0.002 in. thickness.

Continuous Vinyl Foam Sheeting

Continous vinyl foam sheeting has started in commercial production at the plant of *Kyfoam, Inc.,* Bowman Field, Louisville, Ky. The Elastomer process for foaming the vinyl resin-based plastisols is employed and the material is cured electronically by means of high frequency apparatus.

The sheet is marketed in widths up to 54 in., thicknesses up to 4-1/2 in., and, of course, in any lengths. It is available in white or any desired color. Foam vinyl is tough, nonshrinking and resistant to flame, soap and detergent extractions, chemicals, aging, tearing, and abrasion. It does not oxidize, harden or dry out. It has the ability to breathe, due to its interconnecting cells. The properties of the material may be precisely controlled to produce a material that is comparable with soft foam rubber or with hard, flexible sponge rubber.

Among the applications for the material are cushioning, molded inserts, rollers, gaskets, toys, insulation, and it can be heat sealed to textiles and plastic sheeting.

New Polystyrene Plastic Has High Toughness

A new formulation of polystyrene plastic which is claimed to have 10 times the toughness of general purpose polystyrene has been developed by the *Dow Chemical Co.,* Midland, Mich. Known as Styron 480, the material is said to offer greater durability and elongation while still retaining the characteristic properties of other Styron formulations. These include low specific gravity, chemical resistance, dimensional stability, low water absorption and good electrical properties. Parts fabricated of the new material can be stapled, and metal inserts can be molded-in easily.

It is available in a range of opaque colors and can be extruded into shapes or sheet as well as fabricated on standard injection molding machines. The sheet can be stamped, embossed, and vacuum and pressure formed. It is expected to find use in applications such as action toys, refrigerator pans and drawers, portable radio cabinets, high-chair trays, hardware boxes, film reels, hearing aid cases, and formed and decorated sheet.

Versatile Process Speeds Nickel Plating

An improved nickel sulfamate plating process is said to plate about 75% faster, to be more versatile, easier to control and to produce harder deposits with less brittleness than previous sulfamate processes. Developed by the *Hanson-Van Winkle-Munning Co.,* Matawan, N.J., the new bath is said to plate up to 0.007 in. of nickel per hour. This is due to the use of current densities of 140 asf, higher than conventional baths.

This type of bath is commonly used for applying heavy coatings in electroforming, electrotyping and resizing operations. According to the company, the versatility of the improved process permits deposits with low internal stresses and a wide range at specific compresses and tensile stresses. Compresive stresses up to 9x10^{3} psi and tensile stresses up to 18x10^{3} may be gained by varying current density, temperature and concentration of the bath's addition agent.

Other features claimed by the company are: heavy deposits up to 1/2 in.; air agitation rather than conventional pump agitation; and any type of high purity nickel anode can be used.

Specifications for the bath are: nickel sulfamate, 36-44 oz/gal; nickel chloride, 4-6 oz/gal; boric acid, 4-6 oz/gal; and SN-1 addition agent, 0.5-1.5 oz/gal. The pH is 3.5 to 4.2 (electrometric) and the nickel content is 10 oz/gal. Temperatures vary from 75 to 140 F and current densities from 20 to 140 asf.

New Materials, Parts and Finishes continued

Differential Plating Saves Tin

With the normal hot-dip method of tin plating, the thickness of the tincoating on each side of the base metal is equal. In some cases this can be an unnecessary waste of tin. By differentially coating the can material, a coating thick enough to protect the inside of a can from attack may be deposited, while a much thinner one is plated on the exterior.

This so-called "dual coating" is now being carried out on the new acid-halogen electrolytic line at the Aliquippa plant of *Jones & Laughlin Steel Corp.*, 3 Gateway Center, Pittsburgh 30.

For cans holding foods like tomatoes, tomato juice, peaches, etc., the weight of the tin plate on one side of the base metal is equal to 1 lb per base box, while that on the other side is equal to 0.25 lb per base box. A base box, the unit by which tin plate is sold, has an area equal to 31,360 sq in.

An added advantage, according to the company, is that with the increased thickness of plate on the inside, lacquering is not necessary as it is with ordinary electrolytic tin plate which is much thinner.

Jones & Laughlin is now producing this type of tin plate in quantity for use in the fabrication of air cleaners, oil filters, and for other stamped auto parts. For these applications, the thickness of the tin plate is said to be in some cases about twice the thickness of what used to be considered the maximum that could be produced commercially.

New Tumble-Finishing Technique

A new multiple barrel machine that uses what the manufacturer calls slide honing for finishing small parts has been marketed by *BMT Mfg. Corp.*, 110 E. 9th St., Elmira Heights, N. Y. The equipment consists of a 48-in. dia revolving disk with as many as 25 barrels mounted around its circumference. The number of barrels is variable, allowing different sizes to be used, and they may be mounted at any angle, making possible a combination of rotary, centrifugal and slide tumbling actions all at one time. The rotating speed of the disk can be varied from 11 to 28 rpm.

The controlled motion honing is said to remove burrs, flash, tool marks, rust, paint, plating and heat treating scale, yet does not affect the dimensional tolerances of the work pieces. Also, according to the company, such operations as rounding corners, forming fillets, and blending chamfers can all be done on the machine. The versatility permitted by the use of several barrels allows both wet and dry tumbling to be done at the same time.

Two types of barrels are available: a stud-mounted type that bolts directly to the disk, and a quick-adapter type with a safety lever connection permitting instant mounting and removal. Angle adapters are provided so that the barrels can be mounted at any angle. Barrels are available either unlined or with a neoprene lining. The unit with safety cage requires a floor space 7 ft 4 in. by 6 ft 6 in.

Instrument Measures Stresses in Coatings and Finishes

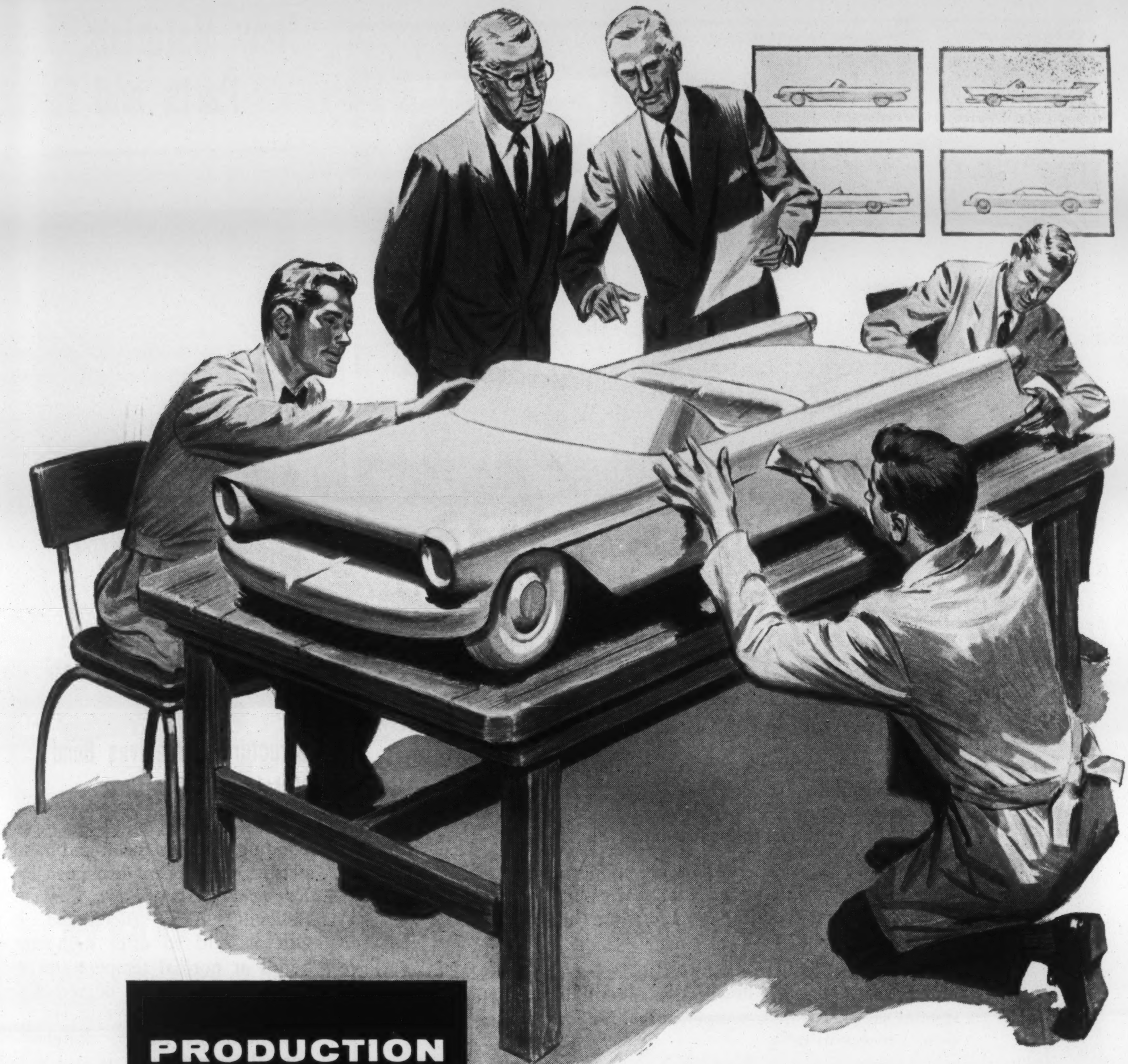
A new instrument for measuring stresses in chemically deposited metals and electroplated metals, as well as paint, lacquer and plastic films has been developed by the *Joseph B. Kushner Electroplating School,* 115 Broad St., Stroudsburgh, Pa. The device, called a Stresometer, can measure stresses ranging from 100,000 psi in tension to 50,000 psi in compression.

The Stresometer (patent pending) is actuated by the deflection of a flat metal disk which dishes in or bulges out according to the shrinkage or expansion of the coating deposited on the outside of the disk. The small amount of deflection encountered at the center of the disk is magnified by a hydraulic arrangement so that a deflection in thousandths of an inch can be read in inches on the linear stress scale.

The instrument can be used directly in the plating tank for control purposes or it can be used for research with a separate tank, for correlating such factors as atomic structure, current density, pH and temperature, with stress. Stress readings may be taken continuously as a function of time or individually in connection with the thickness of the deposit under test. When working with paint, lacquer or plastic films it is possible to follow the curing of the material by readings on the instrument.

Two models are available: one is of high temperature Lucite to be used for electroplated and chemically deposited metals; the other is of metal for use in testing paint, lacquer and plastic films.

(Continued on page 136)



PRODUCTION PROBLEM?

if you use flat-rolled steel talk to a specialist

PROBLEM With present designs and manufacturing facilities, the auto industry needs wide coils of sheet steel with a minimum number of welds. These welds must be cut out before steel goes into the big presses—a costly, time-consuming process.

SOLUTION As a prime supplier to the automotive and other industries, Great Lakes Steel has developed facilities which now produce wide coils of steel in greater lengths . . . drastically reducing the number of expensive welds in each coil. Result: important fabrication savings for our customers.

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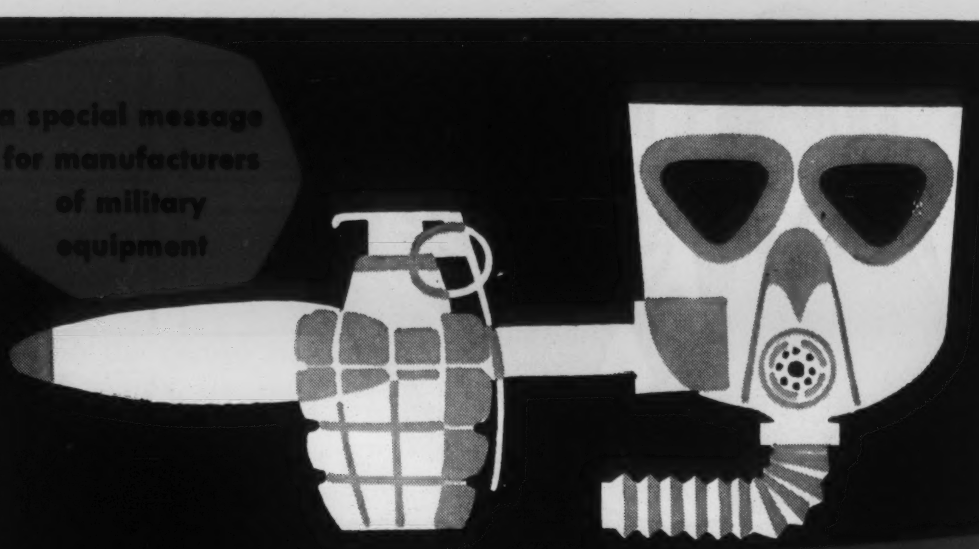

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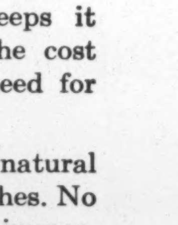
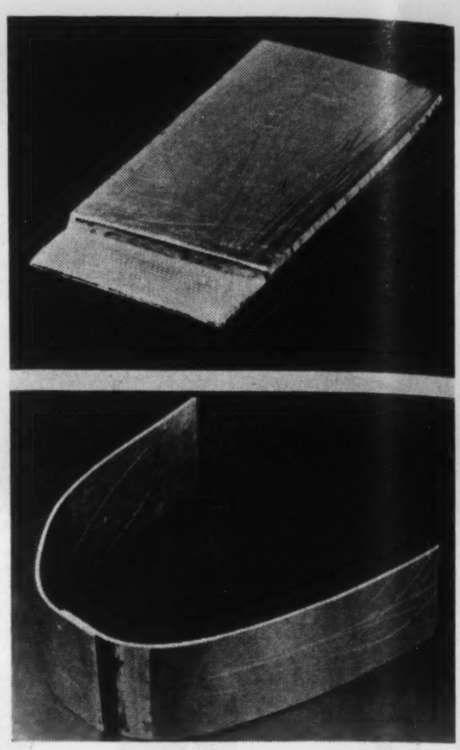


New Materials, Parts and Finishes



Structural Adhesives Bond Metals and Plastics

Two new structural adhesives for bonding metal-to-metal and metal-to-plastics have been developed by the *Rubber and Asbestos Corp.*, 225 Belleville Ave., Bloomfield, N.J. One is said to offer high-strength bonds at normal temperatures while the other has a high degree of flexibility at elevated temperatures.

Bondmaster M615, designed for normal temperatures, is said to yield shear strengths up to 3500 psi (Air Force Tensile Shear Test) and peel strengths up to 19 lb (NEMA), plus high impact strengths. Bondmaster M616 is said to provide shear strengths up to 3000 psi at 180 F, while maintaining a high degree of flexibility.

Portable X-Ray Speeds Inspection of Light Metals, Non-Metallics

A new fluoroscopy and radiography unit for industrial inspection and production control in the light metal, rubber, plastics, porcelain and glass fields has been developed by the *Research & Control Instruments Div., North American Philips Co., Inc.*, 750 S. Fulton Ave., Mt. Vernon, N.Y. The unit is light-weight and self-contained making it easily portable. Called the Norelco MG 60, the

Production Up 40%
Fuel Costs Down 80%

Sections of "track roller shaft" before welding

"Track roller shaft" after TOCCO Induction Welding

with TOCCO* Induction Welding

Here's the story of how one company, a large manufacturer of automotive equipment and farm implements, is using TOCCO Induction Heating to increase production and effect substantial savings at the same time.

Production Increased

When TOCCO Induction Heating replaced oxy-acetylene, output of these hollow "track roller shafts" went up from 220 to 300 pieces per 8 hour shift. The heating cycle with TOCCO is only 55 seconds as opposed to 90 seconds formerly required with gas. Result: much lower labor cost per unit.

Fuel Savings

Fuel costs nosedived from $10.50 per hundred pieces to only $1.95—about $25 per shift saved on fuel costs alone. Other important savings have resulted from a substantial reduction in down time and maintenance costs. Quality of the weld is more uniform with Induction, and hazards of explosion present with former method are eliminated.

If the manufacture of your product involves welding, heat treating, forging, brazing or the melting of ferrous or non-ferrous metals, don't overlook TOCCO as a sound method of increasing production, improving product quality and slashing costs.

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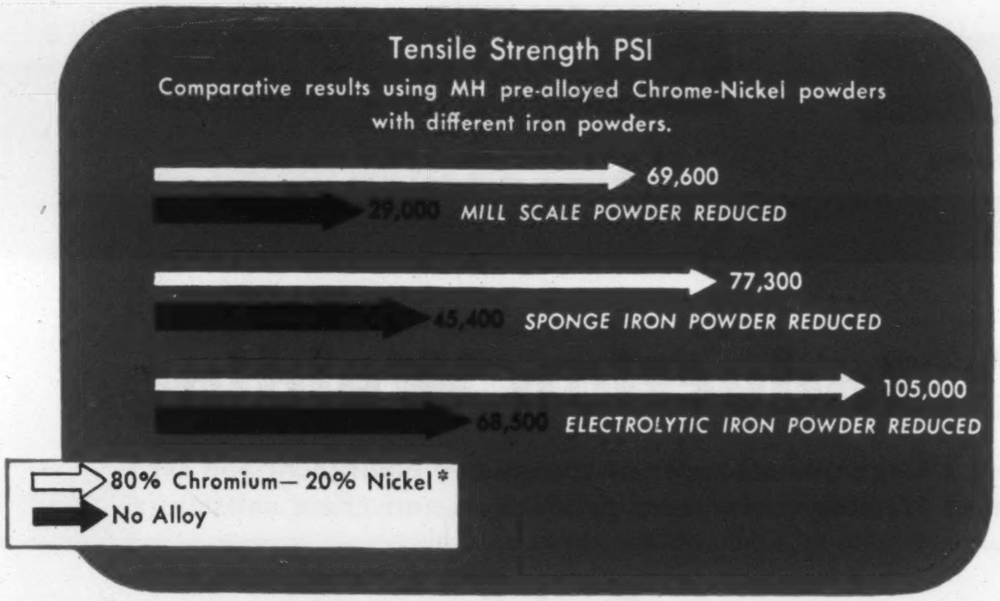
STRENGTH

in any size compact with

MH Chrome-Nickel *pre-alloyed powders*



*1% Carbon added

Regardless of the size of your iron powder compact, you can achieve tensiles up to 120,000 psi in one sintering by the addition of a small percent of Metal Hydrides' pre-alloyed Chrome-Nickel powders.

At one glance, this chart will show you the high physical properties of several iron powders combined with Metal Hydrides' Chrome-Nickel and perhaps show you the way to better the physical properties of your iron powder parts.

Write now for complete information without obligation. Your inquiry will receive prompt, interested attention.

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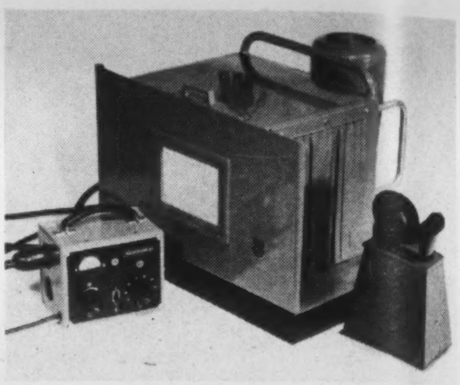
New Materials, Parts and Finishes



unit can detect metallic foreign matter, help in control of fabric layers in rubber or similar materials, and locate contact parts and connectors in insulating material. It should also prove to be of value in the packaged food industry.

It is designed for continuous operation making it suitable for mass production applications. For best results in performing serial inspections, suitable guide rails or a conveyor belt should be used. The unit consists of three components: the x-ray source, the control unit and the fluoroscopy box. The x-ray unit houses the tube and the high voltage and filament transformers in a small oil-filled tank. A built-in air circulator cools the unit. High voltage is controlled by a switch in steps of 5 kvp between 30 and 60 kvp. Power may be turned on or off by a built-in lever switch or a remote control switch.

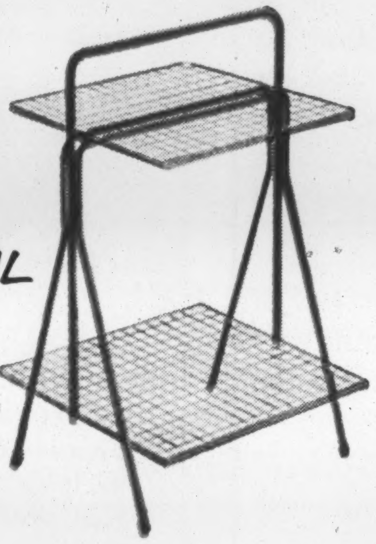
The parts to be viewed are arranged directly behind the fluorescent screen in the front panel of the fluoroscopy box and may be either held stationary or moved as required. A viewing cone may be mounted in front of the screen to aid inspection in brightly lighted rooms. Radiographs can be taken directly on the object or in the fluoroscopic box which has a removable cassette frame.

The MG 60 takes power from a standard 110 or 220-v, a.c. supply. Current consumption is approximately 2 amp and permissable continous output is 4 ma at 60 kvp.

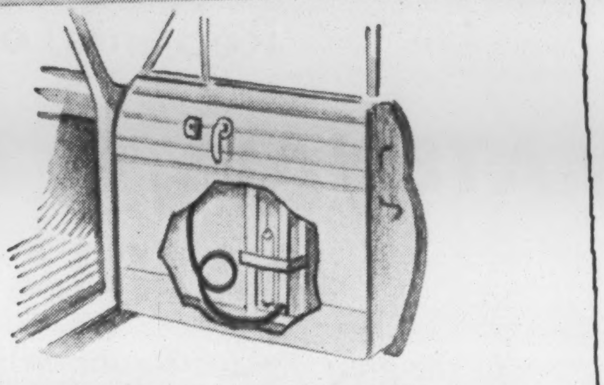
Compacting Press is Adjustable During Operation

Adjustment for changes in compacted part density or weight while

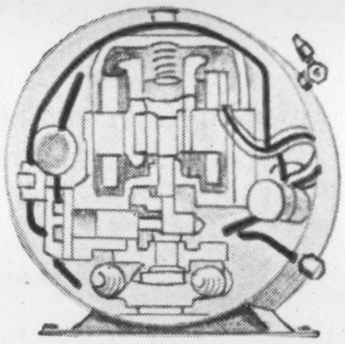
FROM *the Bundy Sketchbook*
TO *jog a designer's imagination*



FRAME FOR OCCASIONAL TABLE



AUTOMOTIVE HYDRAULIC WINDOW LIFT LINES



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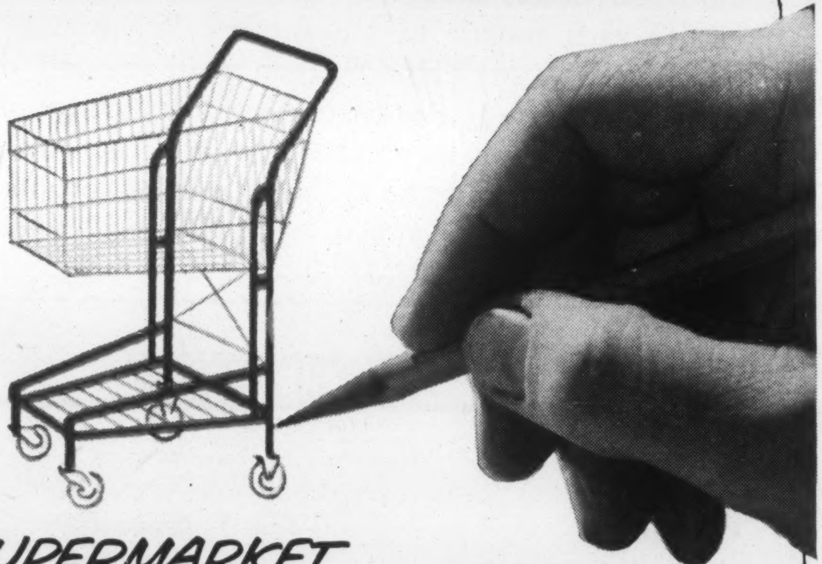
REMARKS Do you have a tubing design that won't jell -- or a fabrication kink you can't untangle? Whatever your tubing headache, why not turn it over to our engineering experts. They offer you years of problem-solving experience, plus the added bonus of Bundyweld, the only tubing double-walled from a single strip (see below).



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continuously rolled twice around laterally into a tube of uniform thickness,

and passed through a furnace. Copper coating fuses with steel. Result . .

SIZES UP TO ⅝" O.D.

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BUNDYWELD TUBING®
DOUBLE-WALLED FROM A SINGLE STRIP

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- Extra-strong
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- Takes plating
- Bright and clean
- No inside bead
- Uniform I.D., O.D.

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Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.

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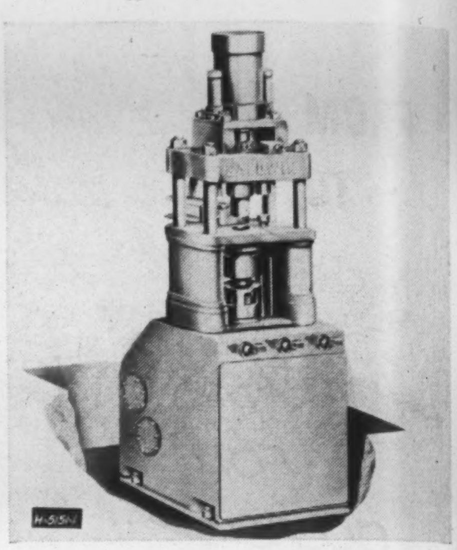
New Materials, Parts and Finishes



in operation is a feature claimed for the new Baldwin-Defiance Model "L" 50-ton compacting press built by *Baldwin-Lima-Hamilton Corp.*, Philadelphia. It is designed for trouble-free production of powdered metal parts.

It is a mechanical, four-column, crank-type press equipped with flywheel, pneumatic clutch and brake, and is driven by a 10-hp, totally enclosed motor through a variable-speed drive. Visual indicators for top punch position, core float down-stop position, depth of fill and ejection stroke read directly to 0.001 in.

Other features claimed for the machine are:

1. Hydraulic head assures accurate control of the pressure being applied, preventing overloading and prolonging the life of the tools and press.
2. Die holder and core rod float independently of each other against pneumatic cushions. An auxiliary stationary core rod can be mounted in the press in addition to the floating core rod.
3. The depth of fill and stroke of the bottom punch are adjusted by two separate controls. The relative position of the core rod to the die is also adjustable to aid in controlling the fill when making counterbored parts.
4. The shuttle type feeder carries the same volume of materials over the die cavity each time. It is air operated, cam controlled and is supported on guide rods with a spring loaded cutoff ring to prevent loss of material.
5. All moving lubricated parts are completely enclosed and sealed.
6. The press can be cycled for con-

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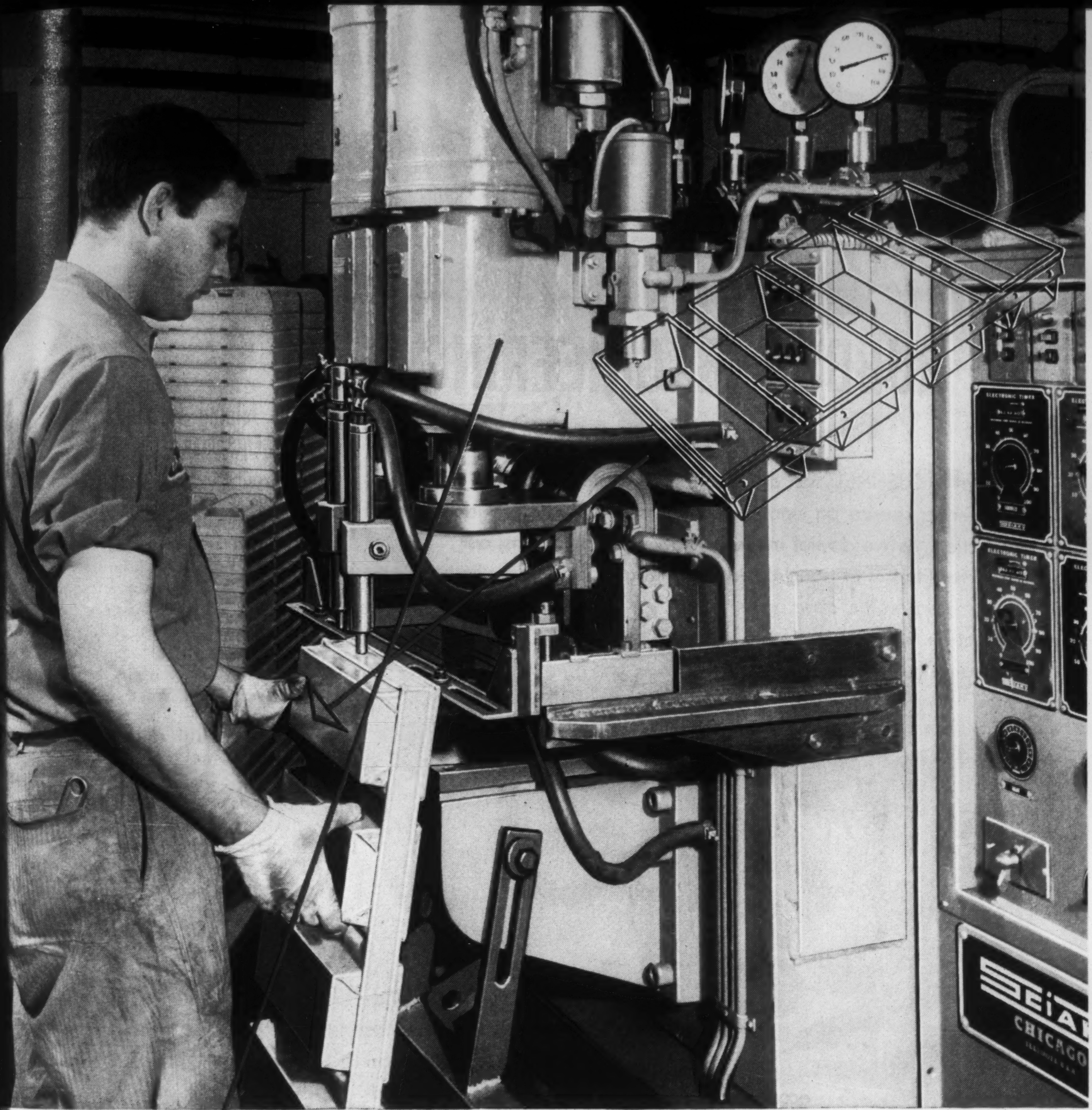

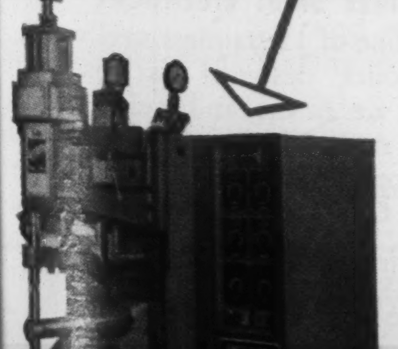

Redesign for Resistance Welding Pushes Trend to Aluminum Bread Pans

The Lockwood Manufacturing Company, Cincinnati, Ohio, manufacture their aluminum bread pans with Sciaky Patented Three-Phase spot welded construction. Rapidly replacing conventional riveted aluminum pans, the spot welded aluminum pans are more durable, more sanitary, safer to handle, and bake a superior product. Further, the production ability and consistency of Sciaky Three-Phase welders reduces fabricating costs. As a result, more and more bakers are using aluminum pans and reaping the benefits of their light weight and long life. For complete details, write for "Resistance Welding at Work," Volume 3, — No. 10

The Three-Phase spot welding of aluminum bread pans at Lockwood is another fine example of Sciaky basic thinking — welders designed to do *more useful work* at *lowest operating cost* with *maximum reliability.*

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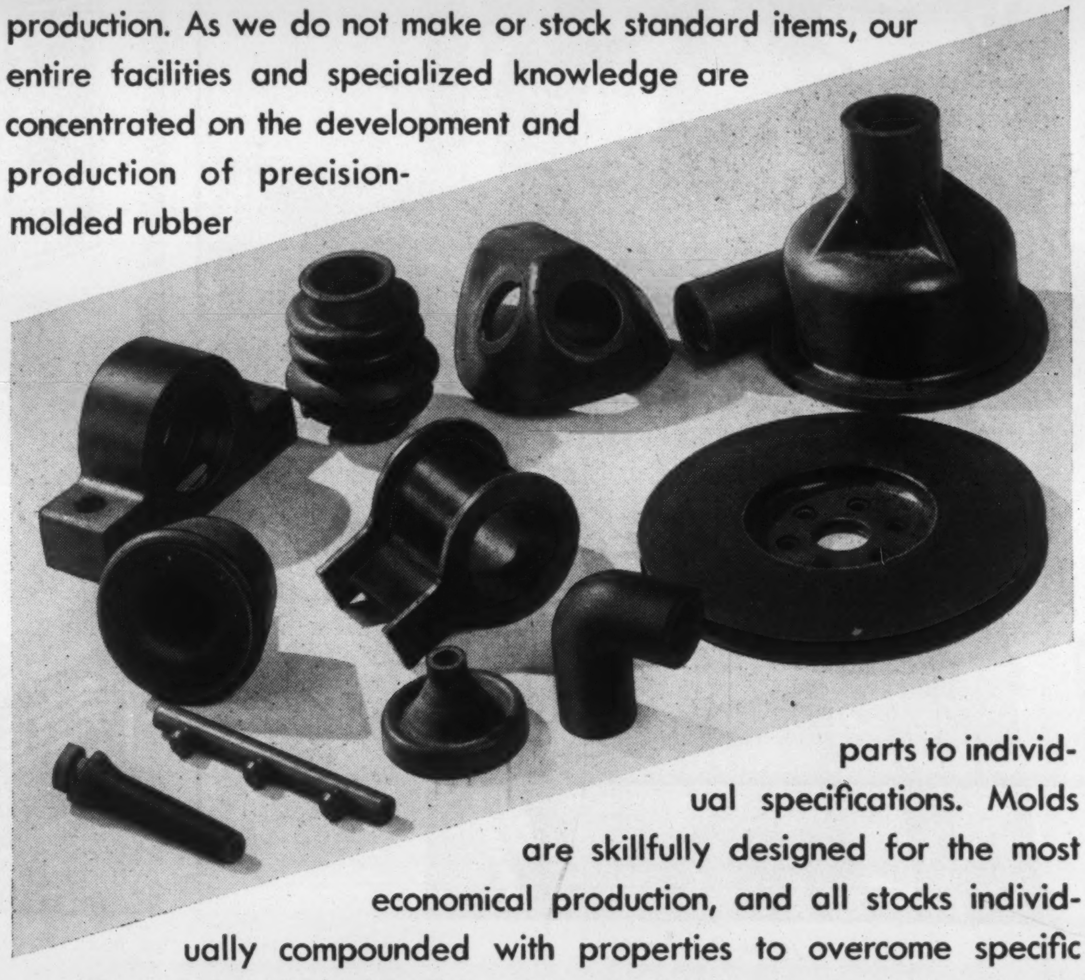

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For more information, turn to Reader Service Card, Circle No. 396

New Materials, Parts and Finishes

tinuous run, semicontinuous run with dwell, single stroke, single stroke with dwell, and inching.

New Joining Materials and Equipment

Grouped here are several new products developed recently by various companies for joining metals. Included are electrodes for welding mild and medium carbon steel, stainless steels, and manganese bronze; hard facing and overlay rods; a cutting and forming electrode; two new aluminum solders; several lines of fluxes for welding, brazing and soldering; and a new a.c. welder.

Rod for Mild and Medium Carbon Steel

A new high speed welding electrode designed for horizontal and downhand welding of mild and medium carbon steel has been marketed under the trade name Rocket No. 24 by *Hobart Bros. Co.*, Hobart Square, Troy, Ohio. It is recommended for welding operations requiring AWS Classes E6012 and E6020 electrodes, such as machinery, low pressure storage tanks, and light structural work.

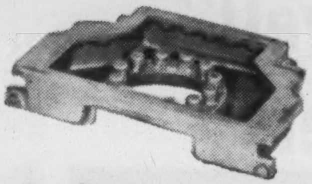
It is a contact type rod said to provide a high deposition rate with less effort and skill on the part of the operator. Spatter loss is said to be low and the slag easily removable with a light tap.

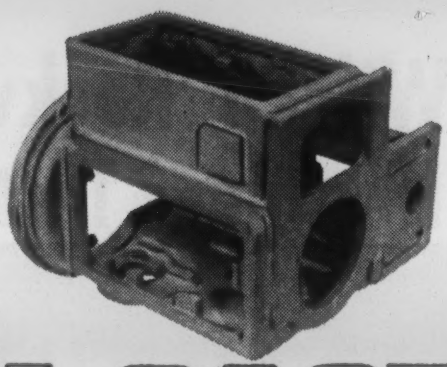
Stainless Steel Electrodes

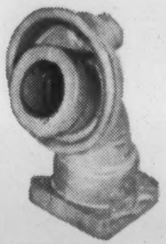
A line of 15 stainless steel welding electrodes designed for use with either a.c. or d.c. and said to provide high rates of deposition has been developed by *Pacific Welding Alloys Mfg. Co.*, Los Angeles 31. According to the company a heavy coating of flux and alloy formula is applied by the extrusion method ensuring a uniform thickness, concentricity and density of coating. The coating is designed to maintain the same physical properties and chemical analysis as the parent metal.

Welds Manganese Bronze

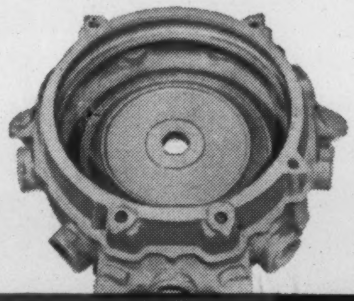
A new electrode has been developed for the fabrication and repair

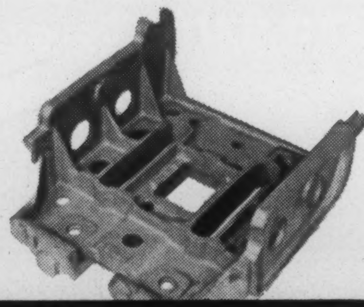






What's *your* need in
MAGNESIUM CASTINGS





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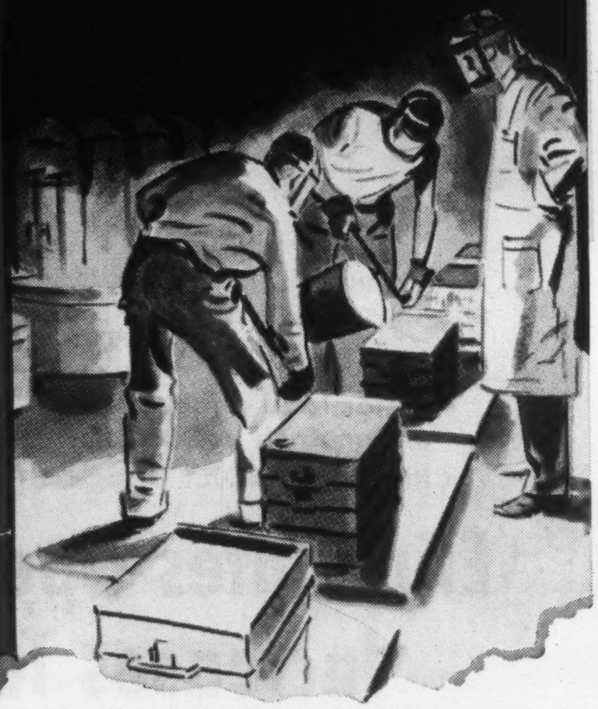

No matter how complicated your magnesium castings are . . . no matter what their size or shape . . . chances are that you can get better quality and faster service by dealing with us.

You save time and money with Eclipse-Pioneer Foundries. We have a quarter century of specialized experience in the production of high-precision castings . . . of *all* magnesium and aluminum alloys.

You get what you want with Eclipse-Pioneer Foundries. We utilize the most advanced service, methods and equipment . . . including resident government inspectors, X-ray analysis and a completely conveyorized production line.

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Check-Chart Shows Versatility of Eclipse-Pioneer Foundries

PROCESS USED	METAL WORKED	
	ALUMINUM	MAGNESIUM
Sand	√	√
Plaster	√	√
Shell Mold	√	√
Die	√	√
Permanent Mold	√	√

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SET-O-MATIC
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Hardness Tester with
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Y MODEL
MOTOR-OPERATED

SET-O-MATIC*
DIAL GAUGE

Eliminates human error. Operator merely applies minor load and taps depressor bar. No setting of dial to zero.

OTHER FEATURES

- **Major load applied under dash pot control**
- **Illuminated Dial Gauge**
- **Major load removed by motor**
- **Illuminated Penetrator**

Eliminates Operations... Increases Tests per Hour

All you have to do with the Model Y WILSON "ROCKWELL" Motorized Hardness Tester is apply the minor load and tap the major load depressor bar. The machine does everything else automatically. The cycle of Major Load operation may be less than 2 seconds.

This speed of test means great savings in time which will reduce your hardness testing costs. Yet it is done to Wilson's high standard of accuracy.

The utter simplicity of setting the SET-O-MATIC* dial gauge eliminates human error. The operator does not have to set the dial. The large pointer is automatically brought to "SET" position when the minor load is applied.

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of manganese bronze without the need for high preheating temperatures, according to the manufacturer, *Alloy Rods Co.*, 4108 Lincoln Highway West, York, Pa. This elimination of high preheating and interpass temperatures is said to remove a major cause of distortion and warpage.

These Bronze-Arc Mn electrodes are said to produce welds with a combination of high strength, ductility and soundness with physical properties comparable or better than those of plate material of the same type, and with basically the same chemical composition. The rods are said to be suitable for welding such manganese bronze castings as gears and pump housings, impellers, mixer beaters, and valves.

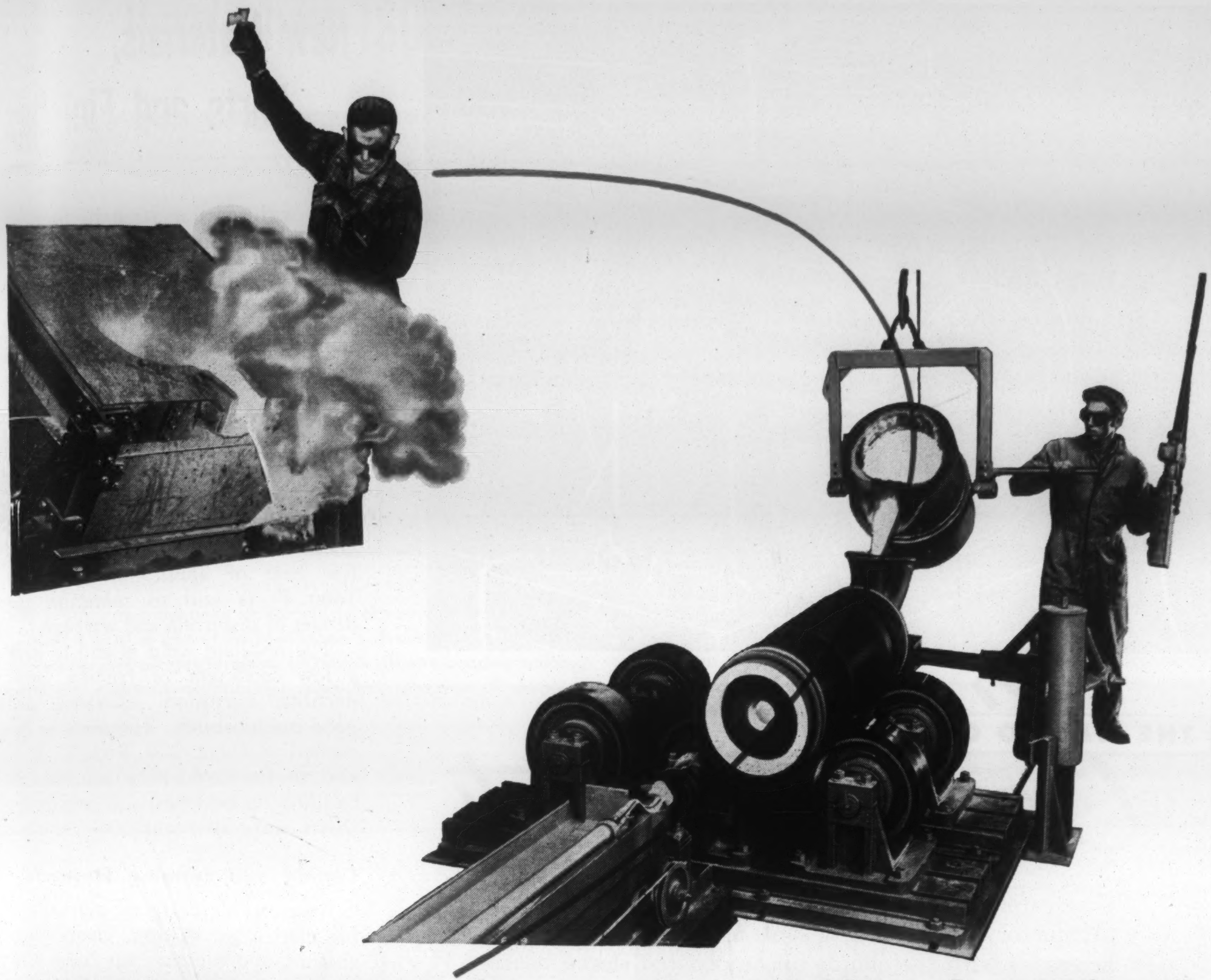
Hard Facing Rod

A hard facing rod developed to withstand the combination of abrasion and heavy impact has been marketed by *Mir-O-Col Alloy Co.*, 312 North Ave. 21, Los Angeles 31. Called BR, the chrome-nickel-molybdenum-tungsten electrode can be used for multiple passes, and the successive layers are said to form a permanent bond with the previous deposits. It can be applied with either electric arc or acetylene torch. The balance of the high alloy content of the rod is said to provide fast burn off, materially reducing the time needed for application. The rod is said to be suitable for rebuilding or hard surfacing such equipment as crusher jaws, crusher rolls, and similar type of equipment.

Hard Facing for Manganese Steel

Said to provide superior strength and wear properties, the Wear-Arc Super WH electrodes have been marketed by *Alloy Rods Co.* for use on manganese steel. The core wire used contains approximately 33% alloy with a carbon content of only 0.35%. This low carbon content is said to prevent spalling and flaking of the deposit under operating conditions causing severe impact.

The rods operate on either a.c. or d.c. current and, according to the company, will join manganese steel to itself or to any other type of



STARTING POINT for good centrifugal castings

All good casting starts in the melt with more accurate control of temperature and closer control of chemical composition. These are both *inherent advantages* of Ajax-Northrup High Frequency, Hi-Speed Induction Furnaces.

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In actual production with an Ajax-Northrup Furnace, alloying elements can be controlled usually within 0.25%; carbon within 0.01 or 0.02%. Melts can be reproduced . . . each time with identical composition . . . or alloys may be varied quickly. Pouring temperature, especially important in centrifugal and precision casting, may be maintained exactly as desired.

Practical savings with Ajax-Northrup Hi-Speed Melting are found in the almost complete recovery of alloying elements. Savings are also realized in an overall reduction in rejects and subsequent grinding operations.

TECHNICAL DATA AVAILABLE: Tell us what you're melting . . . and in what quantities. We'll send you the proper bulletins.

543

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INDUCTION HEATING-MELTING

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Associated Companies: Ajax Electrometallurgical Corp. • Ajax Electric Furnace Co. • Ajax Electric Company, Inc. • Ajax Engineering Corp.

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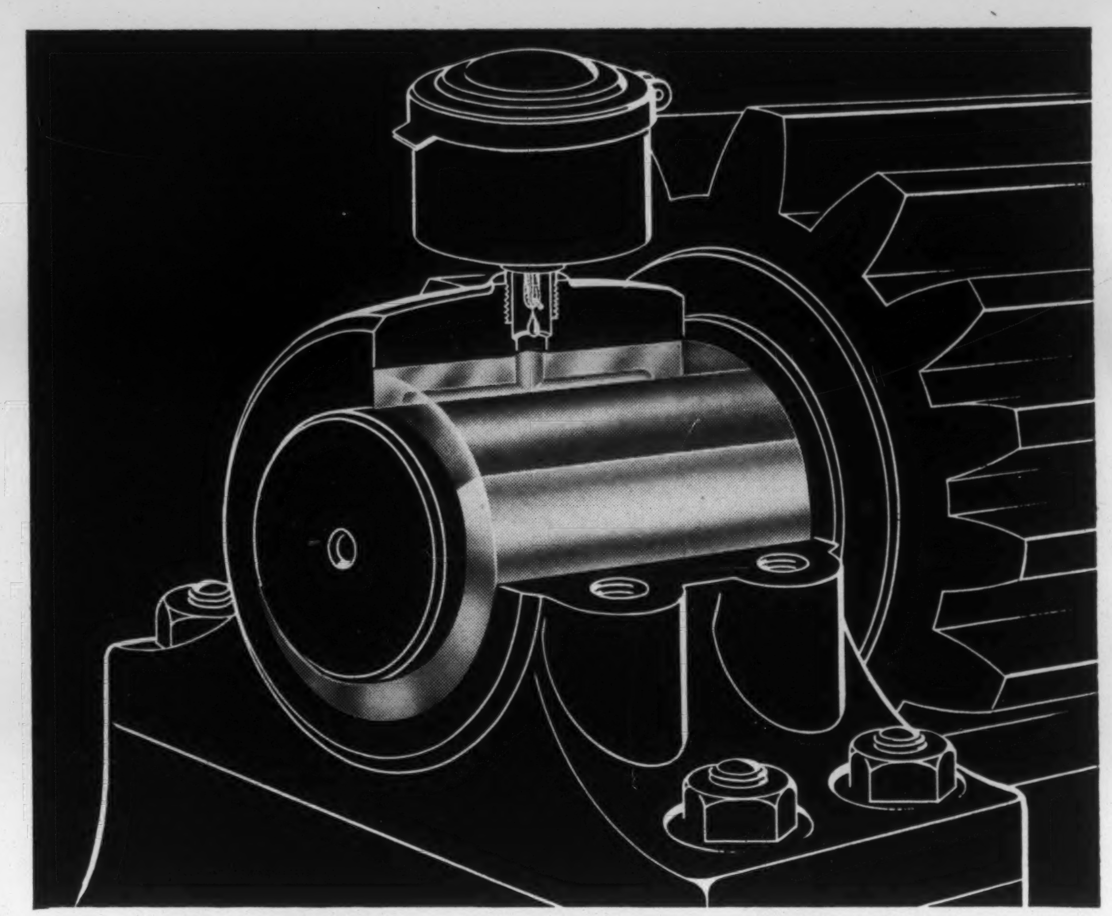

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Cost of added parts

Give careful thought to the added parts required for the satisfactory functioning of some bearing types and not necessary with the simple uncomplicated sleeve bearing. Lock nuts and lock washers needed to fasten some bearing types to the shaft are absent in sleeve bearing design. With the sleeve bearing there is nothing to lock to the shaft. Intricate end covers required for locating or enclosing some types of bearings again are absent in sleeve bearing design. Where the sleeve bearing is to be of the floating type it is simply inserted by hand in the part in which it is to operate. The bearing is delivered to you ready for installation with the actual easy assembly in housing and on shaft all that is left to do. Where the sleeve bearing is to be of the pressed-in type it is simply pressed into the gear, gear box, lever or housing in which it is to function.

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steel with greater strength and rigidity than stainless steel.

Torch Overlay

A low melting overlay for frictional wear resistance whenever a copper base alloy is required has been marketed under the trade name EutecRod 186 by *Eutectic Welding Alloys Corp.*, 40-40 172 St.,Flushing, N.Y. According to the company it can be used for building up or overlaying steel, cast iron, copper and alloys of copper, and nickel. The low heat of application—1400 to 1600 F—is said to minimize the danger of distortion and warpage.

The resultant weld is said to have a low coefficient of friction, good ductility, corrosion resistance and good machinability. Hardness as deposited is about 200 Brinell. It is said to be particularly suitable for building up bearings, and overlaying shafts and valve seats.

Cutting and Forming Electrode

An electrode designed particularly for electric-arc cutting, chamfering, gouging and piercing has been marketed by *Pacific Welding Alloys,* 312 North Ave. 21, Los Angeles 31. Trade marked Cham-Cut, the rod is flux-coated with a special alloy which is said to provide a high cutting rate and is said to be effective on all types of steels including cast iron and stainless steels as well as copper and nickel alloys.

The rod can be used with a.c. or d.c. reverse or straight polarity current and is presently available in 1/8, 5/32, 3/16 and 1/4-in. sizes.

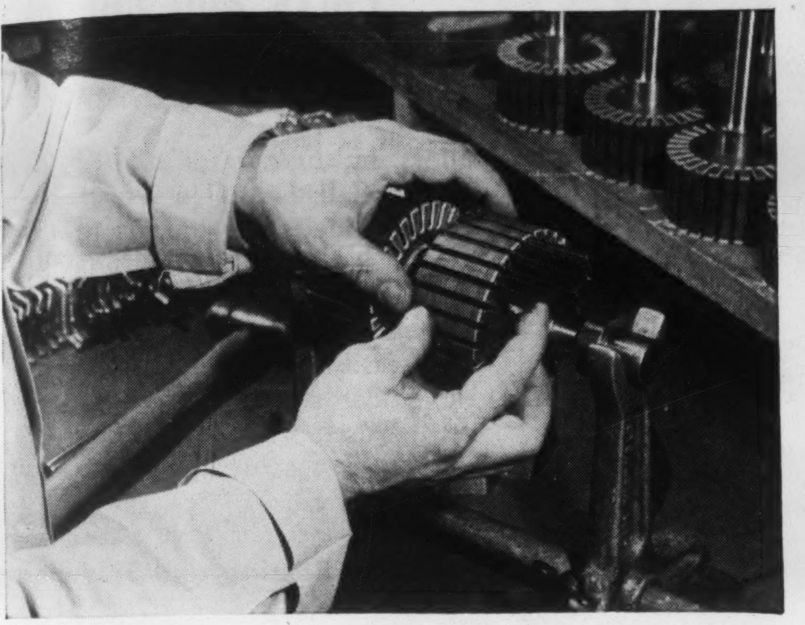
Three New Aluminum Solders

Two solders in wire form for joining aluminum alloys have been marketed by *Belmont Smelting & Refining Works, Inc.,* 330 Belmont Ave., Brooklyn 7. Belmont #60, has a melting point of around 650 F, while Belmont #40 melts at around 400 F. The alloys, in combination with an Aluminum Flux Powder, are offered in extruded wire in diameters of 1/16, 3/32, and 1/8 in. The wire form is said to simplify applications in close working areas.

Another new aluminum solder has been developed for production, filling, sealing and repair operations upon wrought and cast aluminum

Here's how ISOMICA® works for Eclipse-Pioneer*

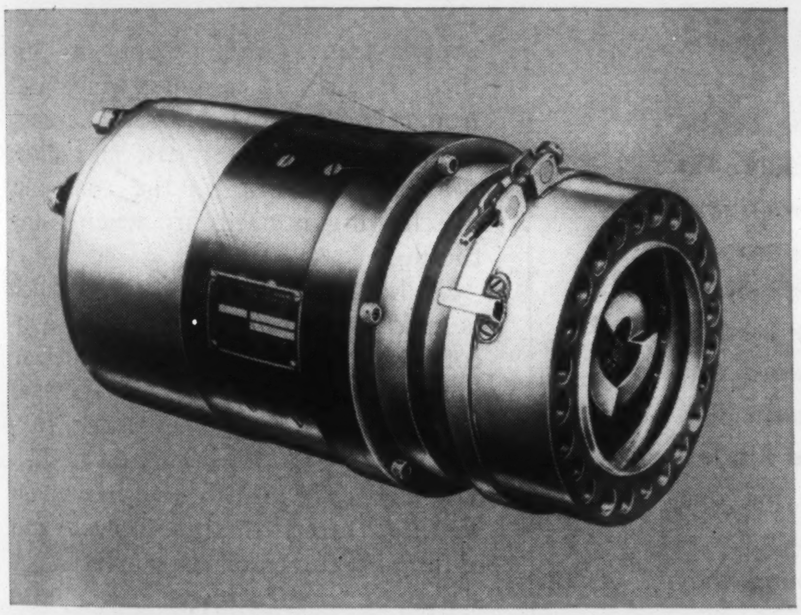
*Division of the Bendix Aviation Corporation



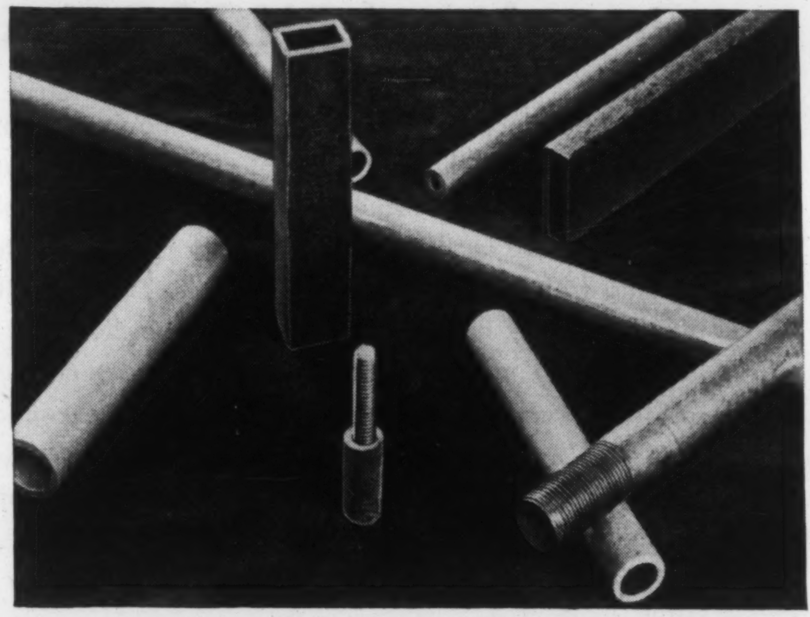
1. **As an assembly time-saver, ISOMICA silicone bonded molding plate** which has been preformed to armature core slot specifications, is used in one of Eclipse-Pioneer's direct-cranking electrical starters for aircraft gas turbines. ISOMICA silicone bonded molding plate has excellent moldability... excellent retention of shape... high degree of homogeneity.

Eclipse-Pioneer
Eclipse-Pioneer

2. **Effective insulation from the laminated body of the armature core** is assured with the insertion of copper coils into the ISOMICA slot cells—the first step in the Eclipse-Pioneer winding operation. ISOMICA molding plate is free from voids, concentration of mica, and pockets of binder. Structure of ISOMICA molding plate allows smooth, right-angle bends without fracturing.



3. **Completed Eclipse-Pioneer direct-cranking electric starter** which has been insulated with ISOMICA molding plate. Some of the many other applications of ISOMICA are flexible slot liners; end-bell insulation; high tension terminals and barriers; angles, bushings and washers; coil insulation, heating element insulation, etc.



4. **Versatile ISOMICA is made in a variety of forms**—miscellaneous ISOMICA tubes (above), tape, molding plate and segment plate, flexible plate and composite materials. These superior materials are made from rolls of thin, continuous mica sheet, impregnated with organic or silicone resins . . . in some cases combined with glass cloth, etc. . . . are uniform in dielectric and mechanical strength.

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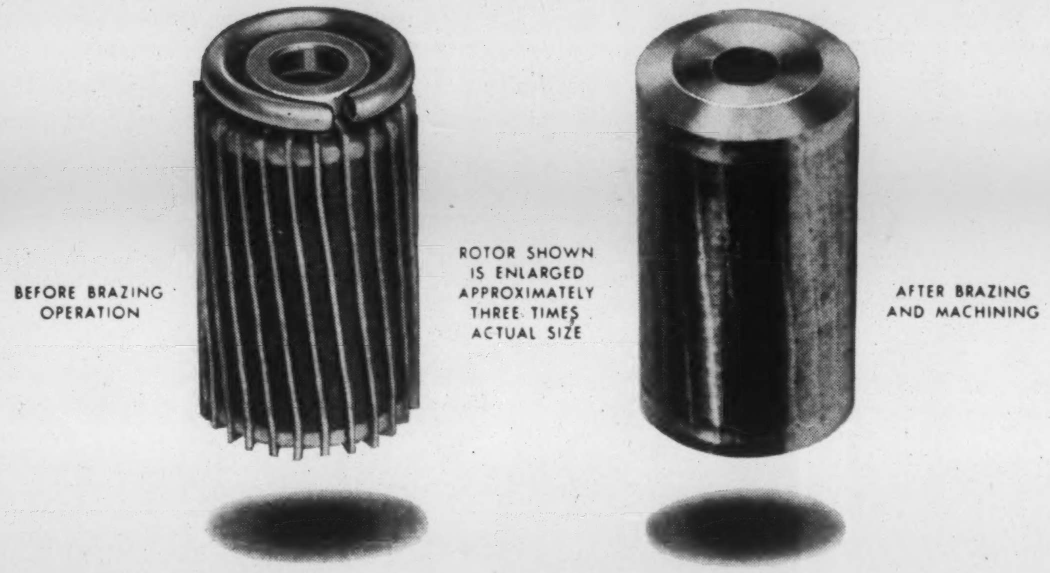
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Elements and components of Servomechanisms must be assembled with incredible precision plus exceptional durability. For instance, operational requirements call for the rotor shown above to be rotated at 400 revolutions per second at temperatures ranging from −150°F to over +200°F. The joints in this bonding must have high conductivity, and no flux can be used in joining. They must also be free of any tendencies toward corrosion or crystallization and must have exceptionally high strength. This special bonding problem was one of the biggest production hurdles facing Servomechanisms, Inc. until the one right solution was found in PHOSON.

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New Materials, Parts and Finishes

alloys by *Eutectic Welding Alloys Corp.* Called AluTin 51, the core of the alloy is a liquid flux which is said to have high wetting properties, reducing the surface tension and allowing the metal to spread and flow easily. The melting range of the solder is 400 to 500 F, and it can be used with torch, furnace, induction, or soldering iron as the source of heat.

Welding, Brazing and Soldering Fluxes

A new versatile flux for welding and brazing is said to provide one flux for all types of gas welding and brazing. Developed by *Andco, Inc.*, 235 Thorne Ave., Orchard Park, N.Y., the Andco Uni-Flux is said to allow welding through lead, beryllium, aluminum, bronze, galvanize, copper, rust, grease, paint, tar and dirt. It also brazes and welds cast iron, chromium alloys, stainless, monel, aluminum, bronze, and silver solder. According to the company, no cleaning is necessary when using the flux.

A line of soldering fluxes which is said to range from mild noncorrosive rosin types to the strong highly active stainless steel types has been marketed by *Alpha Metals, Inc.*, 56 Water St., Jersey City 4, N.J. The fluxes are said to give maximum wetting, rapid fluxing power and minimum corrosive after-effects. A series of non-corrosive rosin base fluxes are available for the electrical, and electronics industries, while several fluxes are available for general purpose soldering. All have water soluble residues which can be removed by washing.

Heavy Duty Welder Aids Production Welding

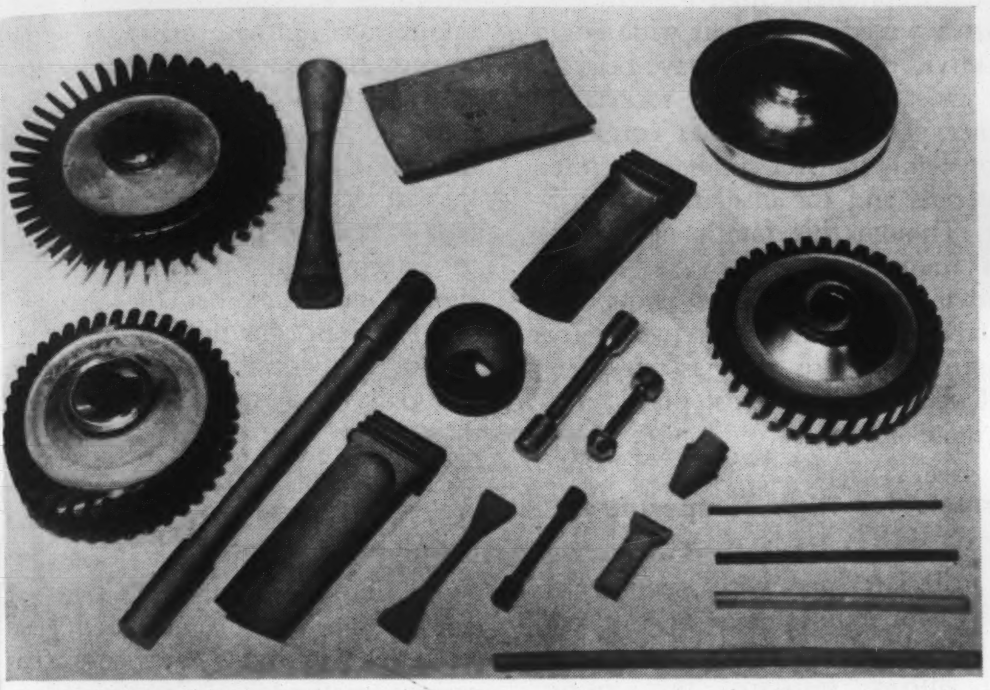
A new a.c. type welder called the Fleetwelder Special has been marketed by the *Lincoln Electric Co.*, Cleveland 17, Ohio. The machine is available in 300, 400, and 500 amp, NEMA-rated sizes. It has a free circuit reactor control of welding current separate from the main transformer which can be adjusted continuously through a wide range of currents. The machines are equally adaptable to sheet steel or heavy plate.

Contents Noted

A digest of papers, articles, reports and books of current interest to those in the materials field.

This Month:

- ***How Ultrasonic Inspection Works***
- ***Nickel Dip's Role in Enameling Steel***
- ***Effects of Weather on Styrene and Phenolic***
- ***Creep Properties of Zirconium***



These parts made of a titanium carbide base cermet represent the type of part for which these high temprature materials are used.

Summary Report: Materials for Jet and Rocket Engines

One of the most important areas of materials research today lies in the high temperature field. Due to the particularly severe service conditions encountered in the rocket and jet engines, organizations working on the development of these engines are accomplising a great deal of pioneer work in the development of materials to withstand these conditions.

At the Semi-Annual Meeting of the American Rocket Society on June 24 of this year, several papers dealing with materials developments in this field were delivered. Here is an abstract and summary of three of the papers, dealing with plastics, cermets and titanium fabrication, each summarizing requirements and some of the steps that have been taken to meet these requirements.

What Can Plastics Do For Rockets?

Two properties of plastics which make them a desirable material for rocket use are corrosion resistance and lightness of weight. Since the fuels and oxidizers used in liquid propellant rockets are highly corrosive, even the stainless steels will not do the trick efficiently. In these cases plastics have been experimented with, and in some cases found to be highly satisfactory.

Mr. Paul M. Terlizzi, of the U.S.N. Air Rocket Test Station, Dover, N.J., roughly described the mechanism of liquid propellant rockets, and the requirements for each component. The accompanying table lists the major components of this type of rocket, and indicates the respective materials requirements for each. He neglects the combustion chamber and nozzle assembly since temperatures of over 4000 F are present, which preclude the use of plastics in these areas.

In the Stored Energy System Container, nitrogen or inert gas is stored under pressure and used to force the fuel to the combustion chamber. Through the use of plastics in this chamber, it has been estimated that a weight saving of up to 30% over conventional steel containers is possible. In the fabrication of the combustion chamber, it has been found that the corrosion of stainless steel tanks by fuels such as nitric acid have contaminated the propellant, resulting in clogging of the injector nozzles and lowering of the efficiency of the chamber wall cooling system through deposition of sludge in the cooling jacket. According to the author, fabrication difficulties encountered with plastic-lined metal chambers have caused engineers to draw the conclusion that the containers should either be constructed wholly

Materials Requirements for Rocket Components

Components	Pressures	Compatability Requirements	Temperatures	Design Details
Stored Energy Container	2200 psi range for one year	Nitrogen or inert gas	−65 to 160 F	Must accommodate attachment fittings for pressurizing lines
Pressurizing Lines	500 psi for a few seconds to about a minute	May be in contact with fuel or oxidizer during storage	−65 to 160 F	Leak proof under design pressures. Adaptable to attachment fittings
Propellant Tanks and Lines	400-500 psi for a few seconds to about a minute	Must be compatible with fuel for 1 yr without contaminating fuel	Varying temperature conditions	Must conform to volume limitations as this component makes up the bulk of the rocket. Must accommodate attachment fittings
Pressure Regulators	2200 psi	No requirements	—	Leakproof, permit the incorporation of valving details

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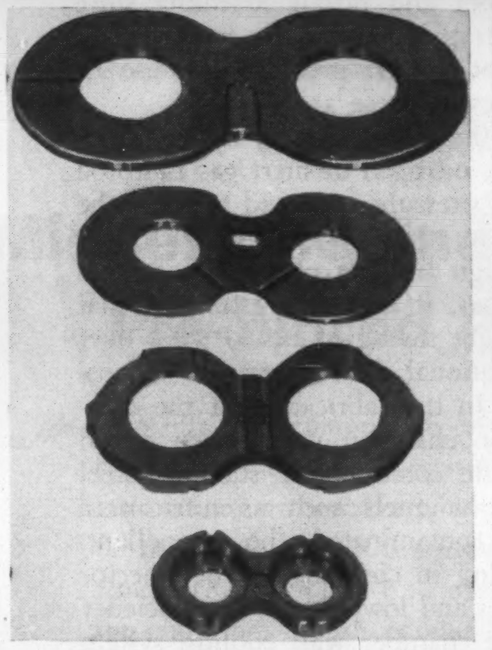

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Available in standard and special formulas developed to cope with specific or unusual conditions. Assure the best combination of physical properties, strength in tension and compression, hardness, and ability to sustain both static and dynamic loading.

Protect the shaft or other moving parts from injury, scoring, and seizing due to temporary interruption or failure of lubrication, and at the beginning and end of a run, when the speed of rotation is insufficient to maintain the oil film.

Will not powder under the most severe conditions of service. Available rough cast or machined to precisely controlled tolerances. They can be machined at surface speeds up to 875 lineal feet per minute.

Castings to your patterns — any size, shape or section — delivered as scheduled and specified. Pattern making, designing and machining when required.

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Contents Noted continued

of plastic or should consist of loose fitting plastics bags inside metal containers.

The fluorocarbon plastics, due to their exceptionally high resistance to corrosive media and their wide range of service temperatures, have been of the most interest to the rocket designer. They are used as cores for propellant transfer lines, for filter materials and for insulation on wiring. Though this family of plastics has found the widest use in this field to date, the author points out that there are many areas where the requirements are not as stringent and where a lower cost plastic may be quite adequate.

Cermets for High Temperatures

Ceramics and metals: Two classes of materials, one with strength at high temperatures but brittle and heat shock sensitive, the other ductile and impact resistant, but losing strength at high temperatures. Combine the two by binding ceramic particles together with a metallic medium and you have cermets. But it's not quite as easy as that.

Mr. R. Steinitz of the American Electro-Metal Corp., pointed out in his paper some of the problems and some of the advances which have been encountered in the development of cermets for use in engines operating at over 1600 F, the present temperature limit for the superalloys. His paper covers the so-called hard metals and especially carbides, borides and silicides of metals such as titanium, zirconium, molybdenum and chromium, since these have shown the greatest promise to date.

The cermet materials which are of the greatest interest today are titanium carbide with nickel or cobalt binder, or with nickel alloys with chromium, molybdenum, or aluminum; boride base materials with or without the addition of materials such as chromium or nickel, using zirconium boride, chromium boride and molybdenum boride as the refractory components; silicide materials on the basis of chromium or molybdenum disilicide; and aluminum oxide and chromium materials.

The properties required for a high-temperature material are high tensile strength, low creep, high stress-to-rupture strength, good heat shock resistance, low oxidation and the highest possible impact resistance to mechanical shock. The property which is still preventing the wide application of these materials is the impact strength at room and elevated temperatures. The best of the cermets show impact resistances of roughly only 20% that of some of the superalloys. Although a great deal of work is presently being done to improve this property, the author points out that the designer should modify his thinking, in order to take into consideration the use of materials which are more brittle than those with which he is accustomed to work today.

Titanium Forming

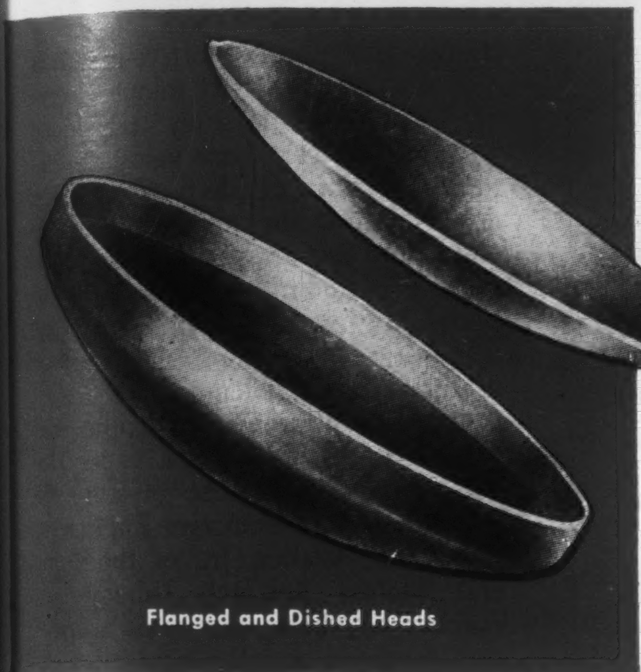
Mr. A. S. Rose of the I-T-E Circuit Breaker Co., summarized generally his company's experience with various methods of forming titanium. Bending and rolling of sheet and bar stock have been done satisfactorily on mills and rollers commonly found in a stainless steel metal shop and forming of parts has been done almost exclusively with Kirksite dies on drop hammers.

Sheet metal RC-A70 varying in thickness from 0.025 to 0.140 has been rolled in cylinders and conical sections with diameters ranging from 10 to 48 in. at room temperature. Sheet titanium 0.180 in. thick and bar stock ranging in section from ½ by ½ to 3 by 4 in. have required hot rolling at temperatures from 700 to 900 F. Forging operations also require heating. Since the forged parts generally require machining subsequent to forging, they may be heated to higher temperatures than those used for sheet forming. Normally the forging temperature is approximately 1800 F.

Spinning is one of the most readily adaptable methods for the production of prototype units for jet engines where cylindrical and conical sheet metal parts are widely used. Since titanium requires hot spinning, gas burners may be set up above the spinning lathe so that they heat a narrow 2-in. band of the titanium cone to which the spinning tool is applied.

(Continued on page 154)

heads---you win



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Whatever your needs in flanged and dished heads, you're a winner every time when you call for heads by Claymont.

We can always meet your most exacting specifications because with us the spinning of flanged and dished heads is more than just a job—it's an art into which we put the most painstaking care and specialized know-how.

Our flanging department can supply you with flanged and dished heads in diameters from 9 inches to 19 feet and in gauges from 3/16-inch to 6 inches. Made in carbon steel, alloy steel or with stainless steel cladding. We are also prepared to handle head forming operations on both ferrous and non-ferrous metal circles supplied by the customer.

Other Claymont products include Stainless-Clad Steel Plates, Alloy and Carbon Steel Plates, Large Diameter Welded Steel Pipe.

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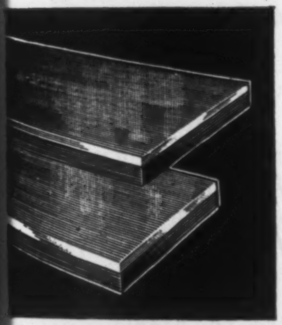
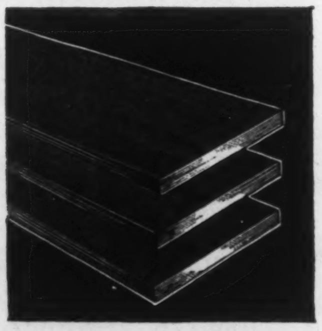


Stainless-Clad Steel Plates



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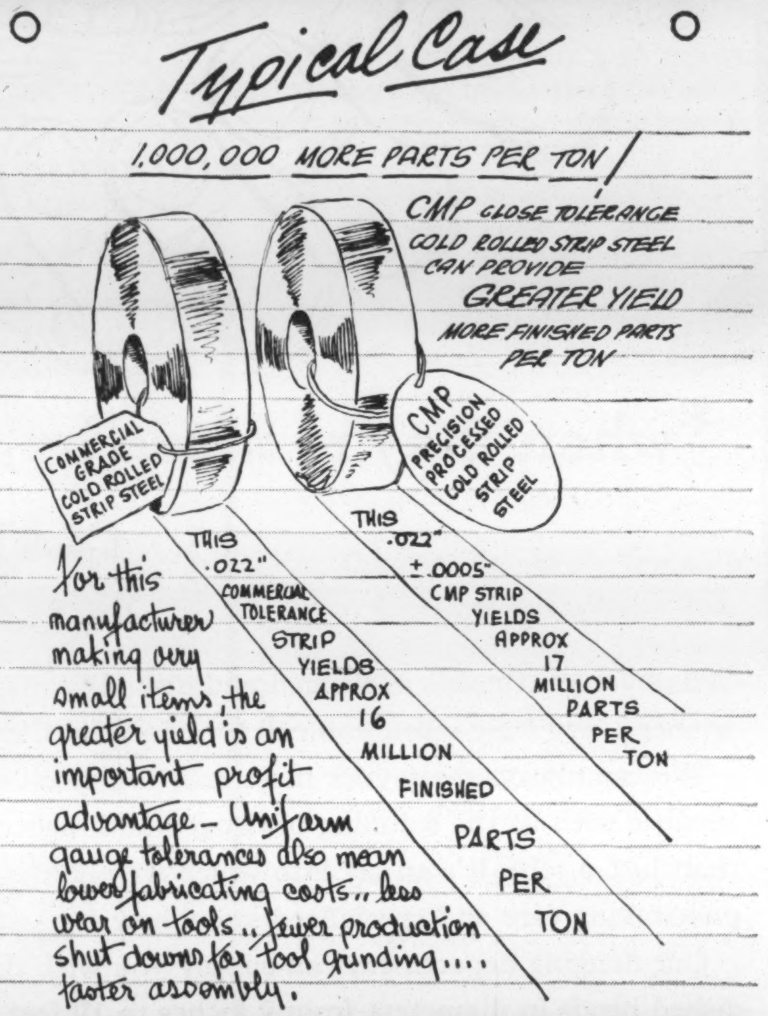
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CAN PROVIDE
GREATER YIELD
MORE FINISHED PARTS
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CMP PRECISION PROCESSED COLD ROLLED STRIP STEEL
THIS .022" COMMERCIAL TOLERANCE STRIP YIELDS APPROX 16 MILLION FINISHED PARTS PER TON
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Some Basics of Ultrasonic Inspection

In the realm of non-destructive testing of materials, ultrasonic inspection has recently come of age. It is no cure-all, but it will do many things other non-destructive methods will not. It can detect minute interface defects while x-ray techniques will only detect volume voids. It permits detection of deep sub-surface defects which the magnetic particle and liquid penetrant methods are incapable of doing. In addition, the portability of ultrasonic equipment makes it attractive for a large number of inspection problems.

What is ultrasonic inspection, and how does it work? In a paper delivered at the Summer Meeting of the Society of Automotive Engineers, Edward F. Weller, Jr., of the General Motors Research Laboratories outlines the basic ultrasonic inspection methods and the principles on which they operate.

The Pulse Echo System

This system locates defects by means of the echo principle which has been used extensively in both sonar and radar. The principle of operation consists of transmitting pulses of ultrasonic vibrations into the material to be inspected. These vibrations are transmitted to the material by means of a quartz crystal transducer which changes dimension when a voltage is applied across its face. If the voltage is of an alternating high frequency, the change of dimension of the crystal is rapid, and ultrasonic vibrations result.

The pulse travels through the material until it hits a discontinuity where part of the energy is reflected and the remainder continues to travel through the article being tested. Ultrasonic waves are transmitted quite readily through solids, but they are nearly 100% reflected at an air or gas boundary. The reflection from the discontinuity is picked up by the crystal transducer which now acts as a receiver, and it is impressed on the oscilloscope screen as a pip. Then after a further interval of time, the reflection from the opposite face of the material returns and is indicated on the screen. This process is repeated rapidly, usually 60 times per sec, to provide a stationary pattern. The necessary elements are a

(*Continued on page 158*)

For more information, Circle No. 391

WE MAKE AND FABRICATE . . .
STRONG, LOW-COST SPIRAL TUBING

Spiral Tubing, another outstanding C-D-F product, is an important new material for the progressive, cost conscious design engineer (and purchasing agent). It is a high strength plastic made from paper or fibre that is spirally wound, then impregnated with phenolic resin or insulating varnishes and carefully cured at high temperatures. The resulting tubes (round, square, rectangular or formed to special shapes) are stiff, sturdy, resistant to crush, with good tensile strength.

This unique product has good dielectric strength with low dielectric loss properties. Moisture resistance and dimensional stability is easily controlled in the manufacturing process. The wide variety of sizes, shapes, forms; the strength; low cost; ease of fabrication; speed of delivery; all combine to make C-D-F Spiral Tubing worthy of your investigation.

PRIMARY APPLICATIONS

COIL FORMS OF ANY SIZE OR SHAPE
- for tuned or untuned RF, IF, oscillator, and other coils used in radio, television, electronic circuits
- for solenoids, relays, circuit breakers
- for transformers
- for permeability tuners

INSULATORS
- for selenium rectifiers
- for electric motors
- relays

BUSHINGS OR SPACERS
- armature shaft spacers
- for mechanical support

SHIPPING PROTECTORS AND FOR SPECIALIZED PACKAGING

BOBBIN TUBES

BODIES FOR PAINT ROLL APPLICATORS

AS A COMBINATION MATERIAL
- with other C-D-F high strength plastics or electrical insulating materials

SIZES

The round tubing ranges from 3/32 to 8″ ID, with wall thicknesses from .0075 to ¼″. The minimum ID of square and rectangular tubing is ⅜″, with 2⅛″ the maximum ID. Wall thicknesses range from .010 to 3/32″.

Standard lengths are from 2 to 4′, with special sizes and grades, plain or impregnated, open for your discussion with our C-D-F sales and engineering staff.

FABRICATION

Spiral Tubing is readily sawed, punched, drilled, tapped, riveted, stamped, painted, depending on the grade; it is suitable for automatic machine operations, but not recommended for conventional machine threading. Waxing or varnish impregnation to improve moisture resistance is usually done on the finished coils by the user.

GRADE SELECTION

C-D-F has mass production facilities for both the manufacture and fabrication of eighteen distinct grades of Spiral Tubing. For example, there's a special punching grade, fine for punching rectangular or square holes near the end of the tube. A relatively soft tube is supplied for difficult stapling or riveting. C-D-F makes high strength automotive electrical bushings from a very hard tubing with high axial compressive strength. Combinations of kraft, chipboard, Diamond "fish paper" Insulation, and other materials are available.

FORMS: ROUND • FORMED • FORMED AND NOTCHED • SQUARE AND RECTANGULAR

See our general catalog in Sweet's Design File for more data, the address and telephone number of your nearest C-D-F sales engineer. Also, write for C-D-F Spiral Tubing folder ST-53, (a workbook showing grades, applications, properties), free test samples, or send us your print for quotation.

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Contents Noted

continued

supersonic pulse generator for producing the high frequency pulse, the crystal transducer for converting the electrical vibrations into mechanical vibrations (and vice versa) and an amplifier for amplifying the received signals before they are displayed on the cathode ray tube.

Ultrasonic Resonance Testing

Instead of applying a pulse of energy to the transducer as in the pulse echo system, with this method the transducer is activated with a continuous high frequency voltage. The quartz crystal is set into vibration and passes the vibration on to the material against which it is pressed. The frequency is then adjusted until the material is vibrating in resonance with the crystal. This means that the frequency applied by the crystal is the same as the frequency at which the piece wants to vibrate. The resonant frequency depends on the velocity of sound and thickness of the material. Since the velocity is known, the thickness can be determined from the resonant frequency.

While the resonant systems are designed to measure thin sections and usually operate over a range from about 0.015 to 0.400 in., they can be used on sections larger than this, in which case harmonics are used. The system can be used to measure the thickness of materials, detect surface irregularities, and find voids in laminated materials.

Ultrasonic Transmission Testing

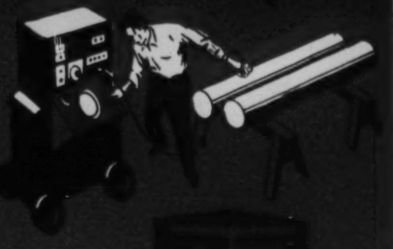
This system consists of sending and receiving crystals with a test tank and an oscillator and detector. Ultrasonic energy is sent through the piece under test, which is submerged in the tank of liquid, and this energy is picked up and measured at the opposite side of the tank. The energy received is an indication of the quality of the piece under test. Irregularities or flaws in the material will alter the energy and will be reflected in the received signal.

How Nickel Dip Helps Enamel Cling to Sheet Steel

The nickel dip, or nickel flash, is widely used in the enameling industry to improve the quality of the coating. A thin nickel film is plated out on the steel by galvanic replac

(Continued on page 161)

Tool Steel Topics

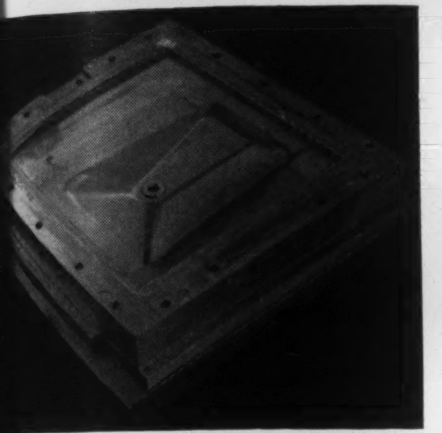


BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

Die Draws 25,000 Stainless Pieces Without Showing Any Wear



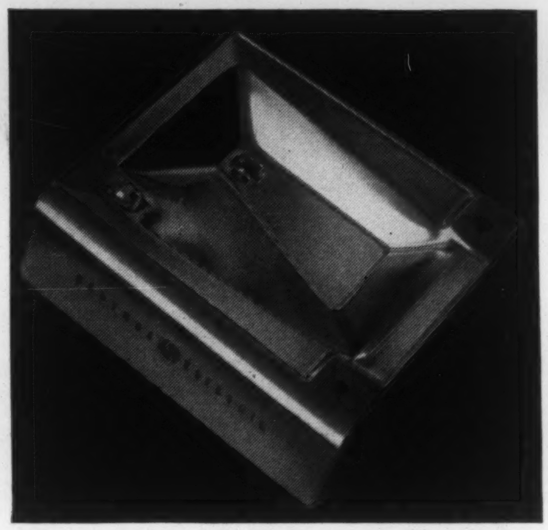
bottom sections of drawing die, made which was used in manufacture of the untain top illustrated at right.

The oblong section shown at right, a stainless-steel top for an electric water fountain, is one of a vast array of interesting specialty products being turned out by L. F. Grammes & Sons, Inc., Allentown, Pa.

To manufacture this part economically, engineers at the Grammes plant required a die having good wear-resistance, low distortion and good resistance to shock. What's more, they also wanted a tool steel that was both easy to machine and heat-treat.

BTR (Bethlehem Tool Room) was selected for the drawing die, which was hardened to Rockwell C-60 before being put to work in a 200-ton press. It's been giving a good account of itself, too. At last report, some 25,000 water-fountain tops had been produced, without any sign of die-wear.

BTR is a tough steel, with outstanding resistance to abrasion. You'll find it ideal in every way for many intricate tool-and-die applications.



BTR is our general-purpose type of oil-hardening tool steel, and has this typical analysis:

Carbon	0.90	Chromium	0.50
Manganese	1.20	Vanadium	0.20
	Tungsten 0.50		

• • • • • • • • • • • • • • • • • •

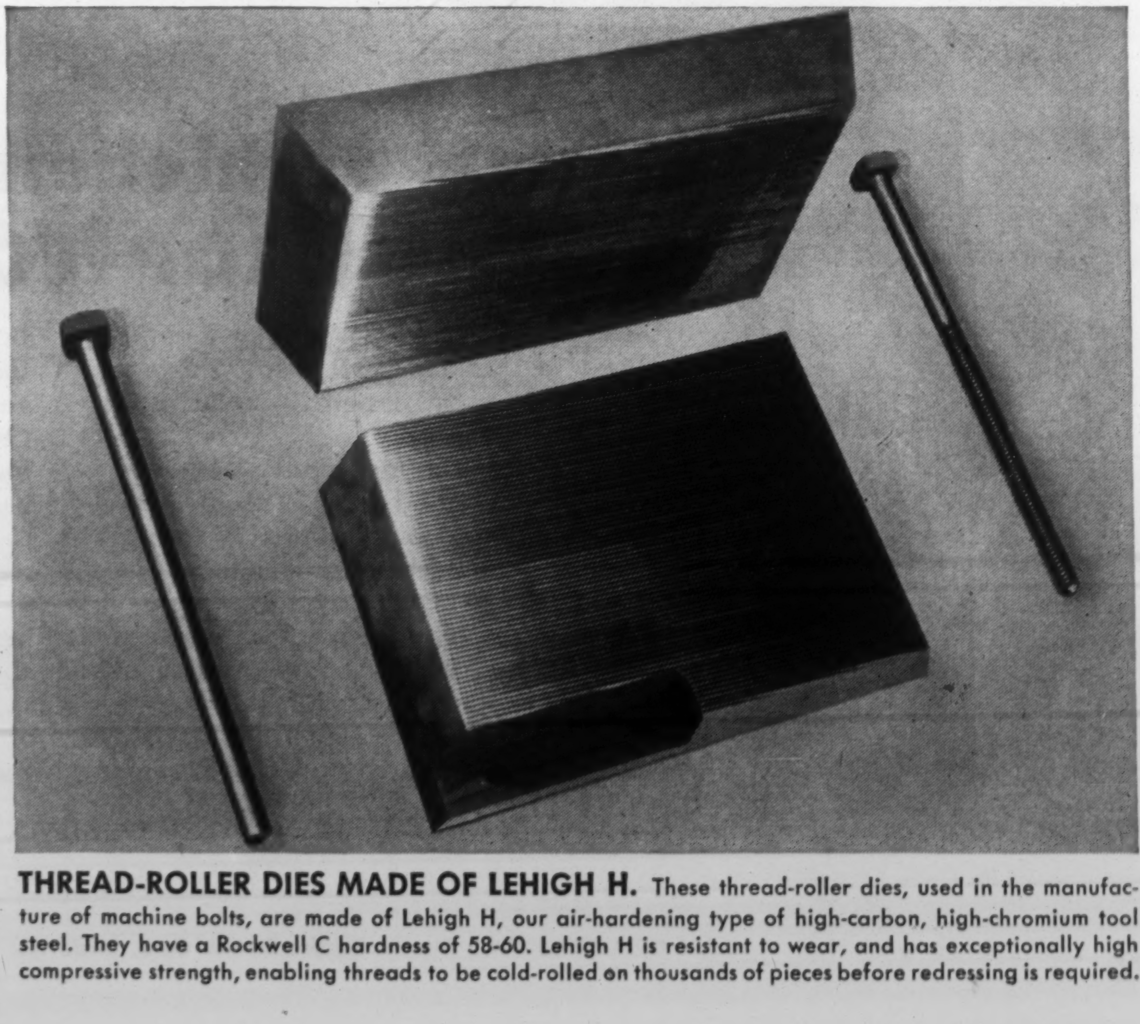
HLEHEM TOOL STEEL ENGINEER SAYS:

Don't Overlook the Interrupted Quench

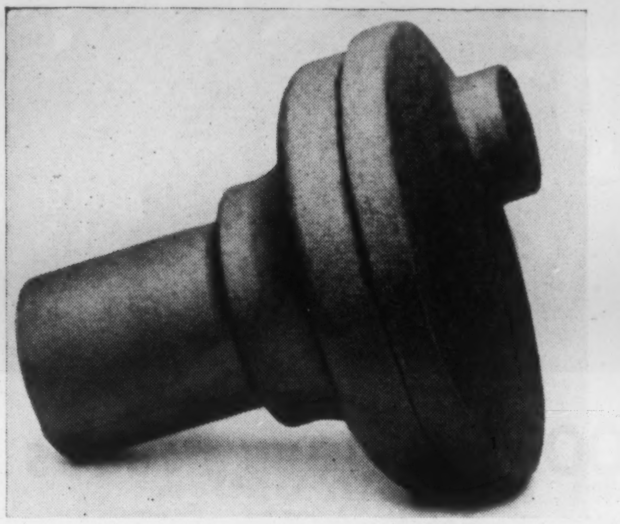
hears such a lot these days about mal annealing, martempering, au- heat-treatment furnaces and a of other modern processes that it is to overlook some of the old-time ures which are still useful. For le, the interrupted quench.

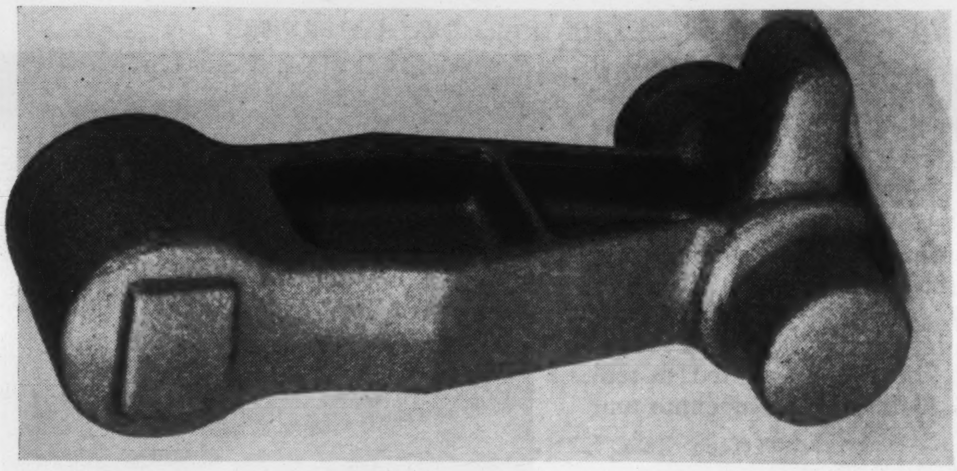
interrupted quench involves ing a tool in water, then removing the water before the hardening ormation has started, and finishing ench in oil. The tools should be from the oil while still warm, ould be tempered immediately. On hardening steels, an interrupted h permits hardening of intricate which might crack if water- hed all the way.

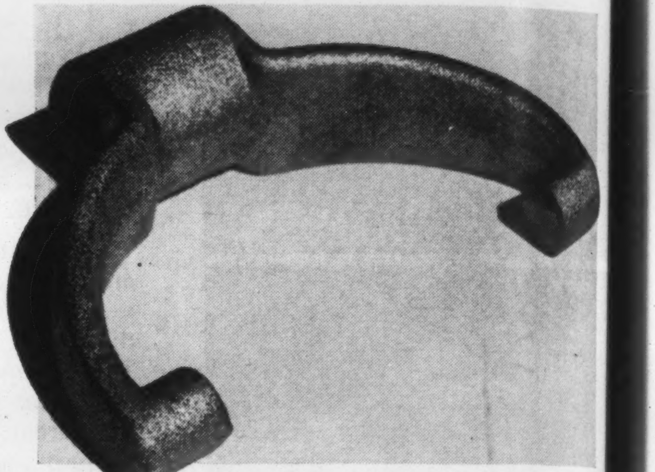
oil-hardening steels, the inter- quench permits hardening of sec- which are too large to harden prop- if oil-quenched all the way. At the time this practice avoids the crack- which might possibly occur if a water quench were used.

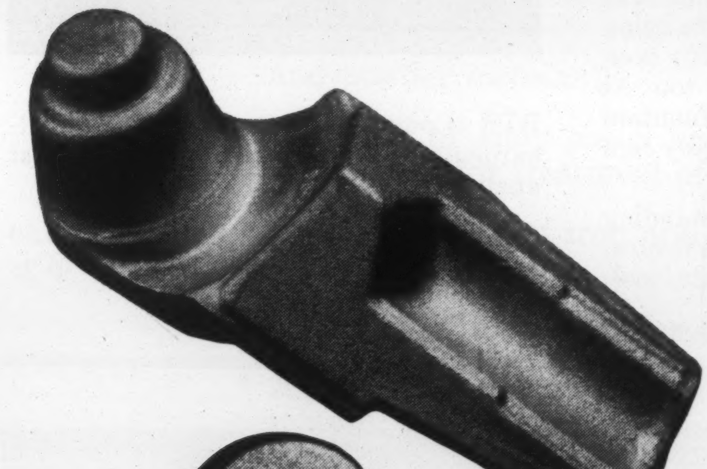


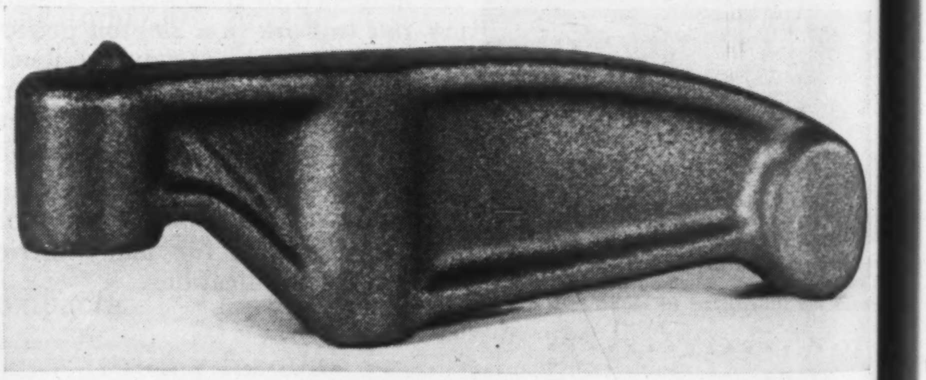
THREAD-ROLLER DIES MADE OF LEHIGH H. These thread-roller dies, used in the manufacture of machine bolts, are made of Lehigh H, our air-hardening type of high-carbon, high-chromium tool steel. They have a Rockwell C hardness of 58-60. Lehigh H is resistant to wear, and has exceptionally high compressive strength, enabling threads to be cold-rolled on thousands of pieces before redressing is required.

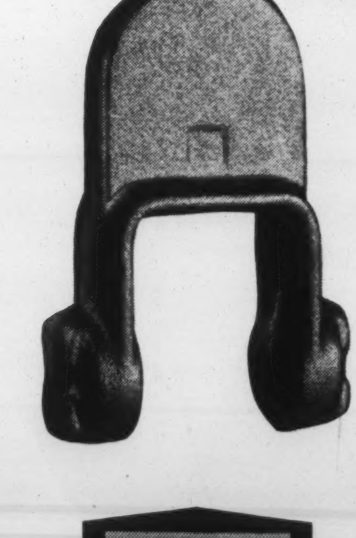












From Bethlehem's Showcase of DROP FORGINGS

In our Bethlehem drop forge shop we have a big display board showing hundreds of the designs we have made in recent years.

The eight forgings shown here were chosen from the board to illustrate, in a small way, some of the sizes and types that Bethlehem can handle. We're equipped to make closed-die forgings ranging in weight from a few ounces to more than 200 lb—and the variety of designs is practically unlimited.

Bethlehem's drop forge division is a completely-integrated operation, embracing every step from the making of the steel to the cleaning, inspection, and shipping of the finished forgings. Our facilities include an up-to-the-minute die shop, steam and board drop hammers to 8000 lb, mechanical presses to 3000 tons, and all necessary heat-treating units.

Why not talk business with us the next time you're in the market? We're able to make you as fine a drop forging as it's possible to buy, in either carbon or alloy steel. Check with us, won't you? We think you'll like our service.

BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporati

For more information, turn to Reader Service Card, Circle No. 369

Contents Noted continued

ment in a nickel salt solution after cleaning, but before applying the enamel to the metal. This nickel film is reported to both insure adherence of the coating over a wider range of time and temperature for the firing process, and to reduce the incidence of delayed fishscales and copperheads.

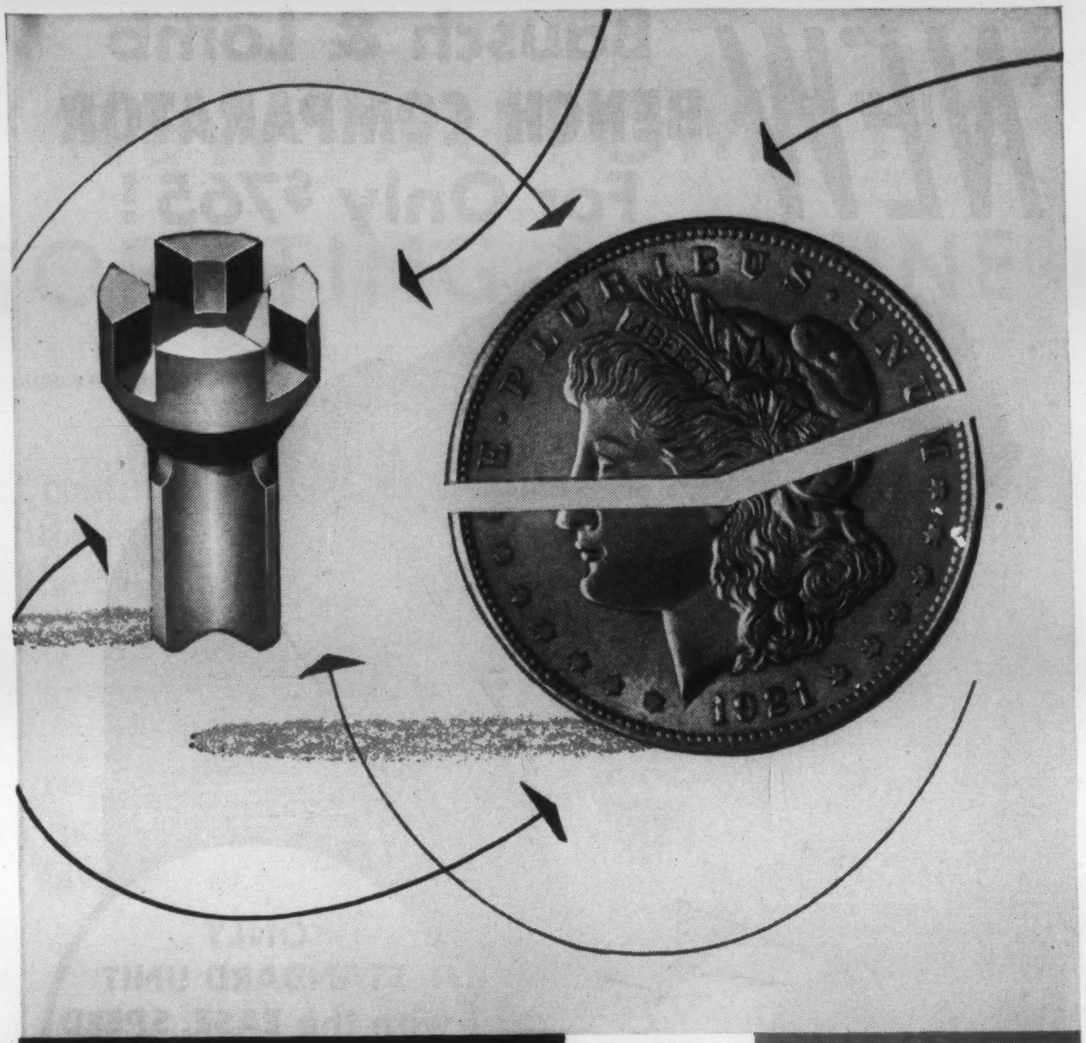
In a report published by the National Advisory Committee for Aeronautics in June 1954, D. G. Moore, J. W. Pitts, and W. N. Harrison of the National Bureau of Standards report the results of their work in determining the effects of firing time and weight of deposited nickel on the adherence of a cobalt-free and a cobalt-bearing ground-coat enamel on both enameling iron and a titanium-bearing low-carbon steel. As well as determining the effects of the nickel dip on the adherence and fishscaling tendencies of a typical ground-coat enamel, the authors were attempting to determine the most probable mechanism through which the nickel aids in the development of the bond.

The authors found that the nickel dip produced a large improvement in adherence index with specimens fired for short times, but that the effect of the nickel on adherence decreased markedly as the firing time increased. At 1550 F the maximum benefit from the nickel on the adherence index occurred with firing for 2 min. Also, under most conditions, the nickel dip produced a greater increase in adherence with the titanium-bearing low-carbon steel than with the enameling iron.

To develop the maximum adherence on the titanium-bearing steel, the optimum weight of nickel deposit was found to vary from 50 to 120 mg. per sq ft depending on type of cleaning used and type of enamel applied. The nickel dip was also reported to reduce fishscaling.

The authors seem to agree that the function of the nickel dip in improving adherence is associated with galvanic attack. The nickel apparently deposits selectively on more cathodic areas of the steel surface, thus forming local galvanic cells that begin to function immediately after the enamel fuses and wets the metal surface. During firing, the iron members of the cells corrode while the nickel areas are cathodically protected. This process roughens the surface and the coating seems to anchor itself by invading the undercut areas.

(More Contents Noted on page 162)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This intricately contoured valve is precision cast by the Microcast process. It was previously machined from a sand casting at a cost of over twice that of the Microcast method. Now Microcast saves this customer 53% on each valve produced.

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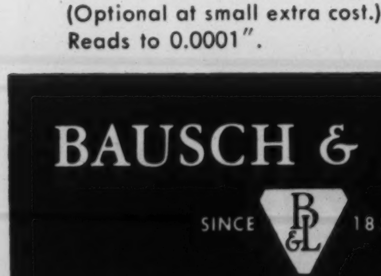

Make fast, accurate measurements with the easily attached micrometer stage. (Optional at small extra cost.) Reads to 0.0001″.

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Quality Control INSTRUMENTS

Contents Noted continued

How Weather Affects Styrene And Phenolic Plastics

With the increasing use of plastics outdoors, the effect of weather on these materials has become of great interest. Tests conducted over a period of four years by the Monsanto Chemical Co. have just been completed and the results reported in a paper delivered to the American Society of Mechanical Engineers in June of this year by J. R. Taylor and C. G. Adams of that company.

The specimens tested were molded from crystal styrene, gray pigmented styrene and a black pigmented wood flour-filled general purpose phenolic. The two styrene materials were exposed to determine the effect of pigment on the weatherability of the material. The wood flour-filled phenolic was chosen because it is the most widely used material of the phenolic family. Three exposure sites were chosen in three localities which experience different types of weather conditions. One had high temperatures, moderate to high rainfall and high humidity; another had high temperatures, low rainfall and low humidity; the third had extreme seasonal weather.

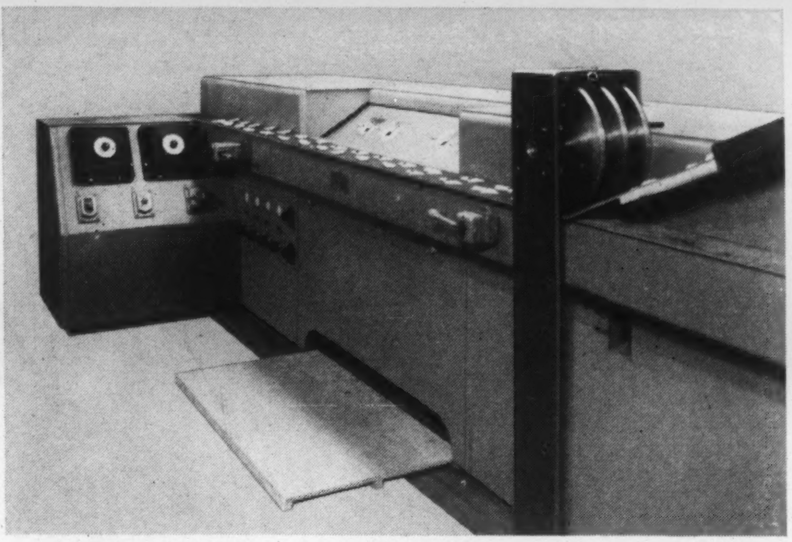
The mechanical and electrical properties of unpigmented styrene were seriously degraded by exposure for a period as short as three months, and this degradation was closely associated with the amount of sunlight reaching the material. The addition of the pigment to the material greatly improved its resistance to weather. The surface of both styrenes was roughened after four years by erosion, and though the surface of the pigmented styrene had yellowed considerably, the strength properties showed little change.

The phenolic material was degraded mechanically and electrically by conditions of high humidity, high temperatures and moderate rainfall. The hot, dry climate did not seem to affect the strength and electrical properties during the exposure period. The loss of weight experienced by the material was attributed to evaporation and erosion.

Creep Properties of Zirconium

The behavior of zirconium during and after annealing is markedly different from that of many of the

Sensational NEW AUTOMATIC SPRAY DECORATING MACHINE



with no interruption of continuous painting production, automatically washes masks right in the machine and returns them to painting position clean and dry.

No other machine ever required so few masks—only two per color. Permits tremendous savings in mask investment.

Simultaneously paints two colors on one part or one color on two parts.

Capacity of up to 3,600 pieces per hour, depending upon handling facilities and decoration applied. Fully adjustable as to amount of paint applied, number of coats and speed of operation. Clean, filtered air is induced for exhausting purposes, and foreign matter is kept from the spray area.

Installation for large toy manufacturer. Work flows continuously and directly from the molding machine to the painting operation, and thence by conveyor to assembly.

ENORMOUS SAVINGS IN COLOR DECORATION OF 3-DIMENSIONAL PARTS

9 10 11 12
9 10 11 12

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(Made by Patented Process)

Permit rapid wet painting, one color after another. Clean, sharply defined letters and decorative effects obtained on intricate die castings, stampings and plastic forms by accurate control of painted areas. No fogged edges. After-wiping or buffing-off of overspray unnecessary. The "loose" inside of letters and numerals, such as "0" and "6" is held in position by arched bridging to eliminate objectionable "ties". **Plug-type masks** (keep depressed areas clear, while spraying background); **lip-type masks** (protect background while painting depressed areas); and **block-cutout, plane-surface type masks.**

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Contents Noted

continued

other metals. The major changes in hardness, annealing texture and electrical resistivity take place long after recrystallization is apparently complete according to metallographic examination. These characteristics make the annealing process of vital concern to the creep properties. The material presently available on creep properties of unalloyed zirconium neglects the importance of proper annealing, according to M. J. Manjoine and W. L. Mudge, Jr. In a paper presented before the 57th Annual Meeting of the American Society for Testing Materials in June of this year, Mr. Manjoine and Mr. Mudge report data which show the dependency of creep properties on the state of anneal of the material, and also detetrmine the creep properties of unalloyed zirconium at 500, 600, and 750 F.

By careful control of the annealing process, the authors found that the creep strength depends on the state of anneal and increases with increasing hardness. Because of the large plastic strain on loading, the creep strain up to 600 F is small and can, in most cases, be neglected. Above this temperature it must be considered in designing. The creep strength drops almost linearly with temperature between 500 and 600 F, but begins to drop much more rapidly at some temperature above 600 F.

The rupture strength for 5000 hr is a similar function of the temperature and is the same as the creep strength for a rate of 10^{-6} per hr. Therefore this creep strength can be used up to 750 F for design purposes below a life of 5000 hr.

(Book Reviews on page 166)

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THIS BOOK . . . will answer all your BRONZE CASTING PROBLEMS

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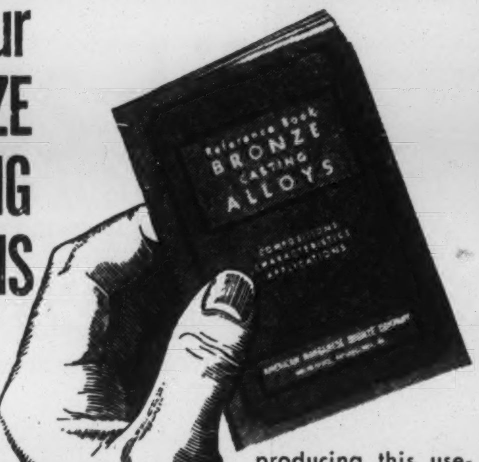

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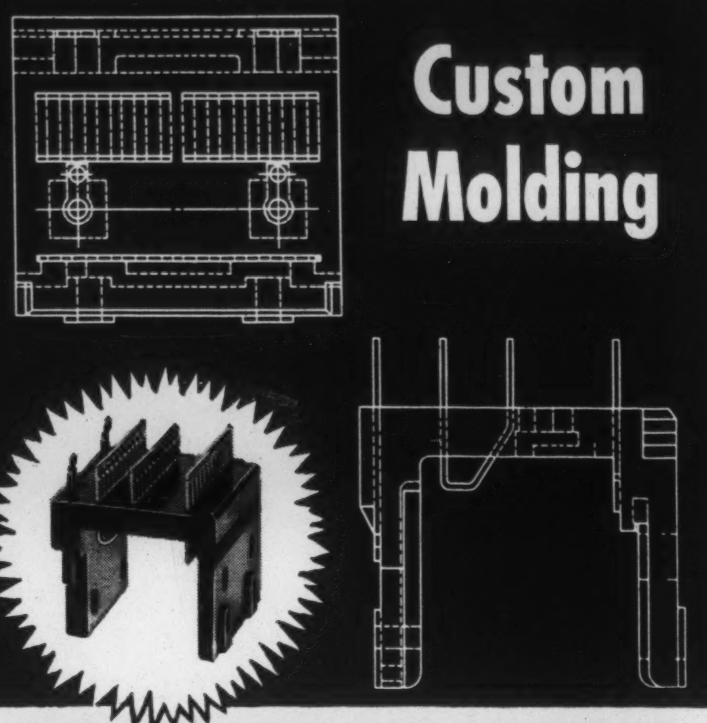
Custom Molding



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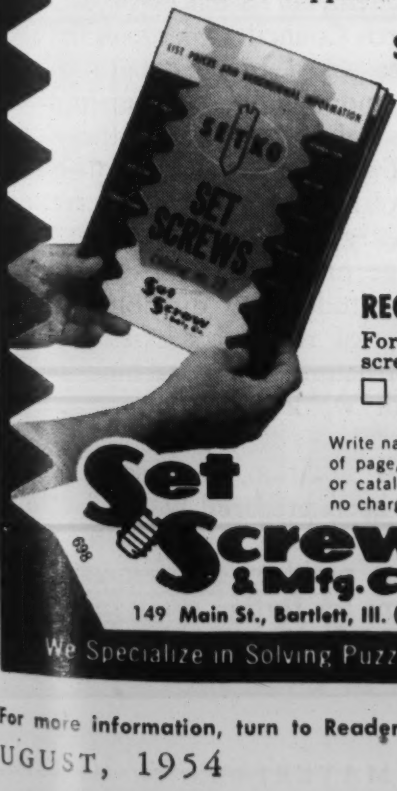

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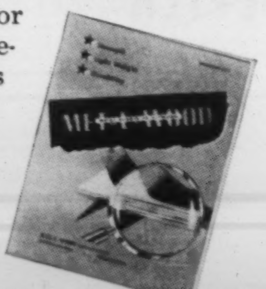

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Contents Noted

Books

Copper. *Edited by Allison Butts. Reinhold Publishing Corp., New York 22, N. Y., 1954 Cloth, 9 by 6 in. 936 pp. Price $20.00.*

This monograph is a comprehensive reference work on all the important phases of the chemistry and metallurgy of copper. It contains 46 chapters written by specialists in the field.

Chapters cover copper minerals and ore deposits, smelting and refining, melting and casting, hydrometallurgy, physical and mechanical properties, copper alloys, hot and cold working, diagrams of binary and ternary copper alloys, applications, copper compounds, and uses of the element in organic chemistry. Bibliographies are included in most of the chapters.

This is the most complete treatise on copper ever published and will be an invaluable addition to the reference shelves of all metallurgists, engineers, chemists and executives who refine, fabricate or use copper and copper products.

Residual Stresses in Metals and Metal Construction. *Edited by William R. Osgood. Reinhold Publishing Corp., New York 22, N. Y., 1954. Cloth, 6 by 9 in. 363 pp. Price $10.00.*

This monograph was prepared for the Ship Structure Committee to summarize and assess the present state of knowledge of the effects of residual stresses upon the performance of various structures. Under the guidance of the Committee on Residual Stresses of the National Academy of Sciences—National Research Council, experts on the subject were asked to contribute papers to the monograph. The main body of this volume consists of these papers.

Twenty-two papers contributed by specialists in the field from this country and over-seas offer a wide range of information on the origin, magnitude and distribution of all types of residual stresses existing in a structure or a machine resulting from welding, machining or other causes.

In addition, a special summary has been prepared by the Committee covering many aspects of the residual stress problem and suggesting programs for further study and research.

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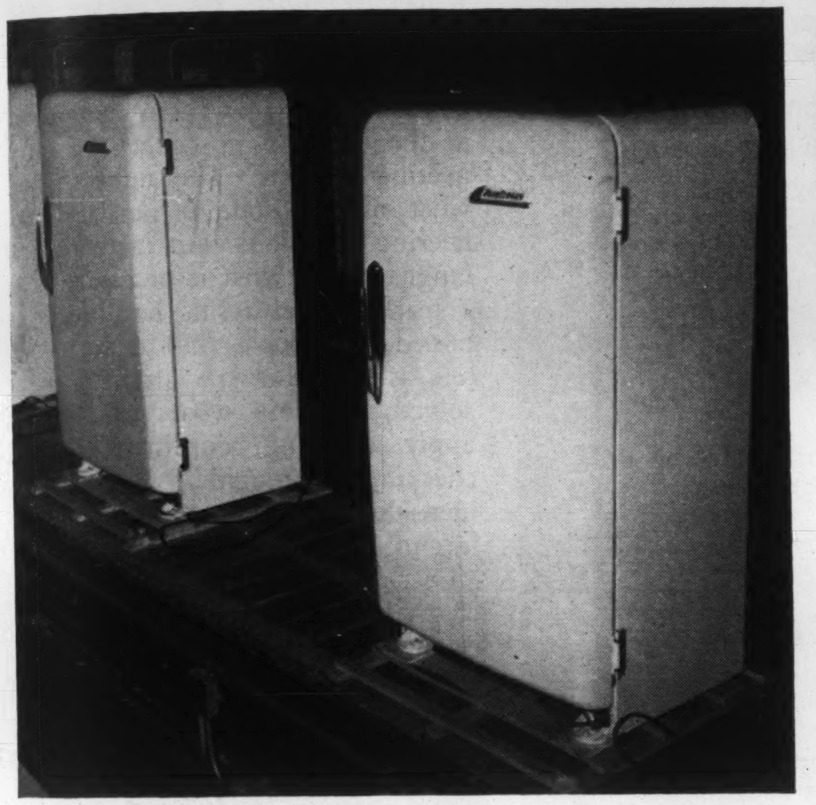

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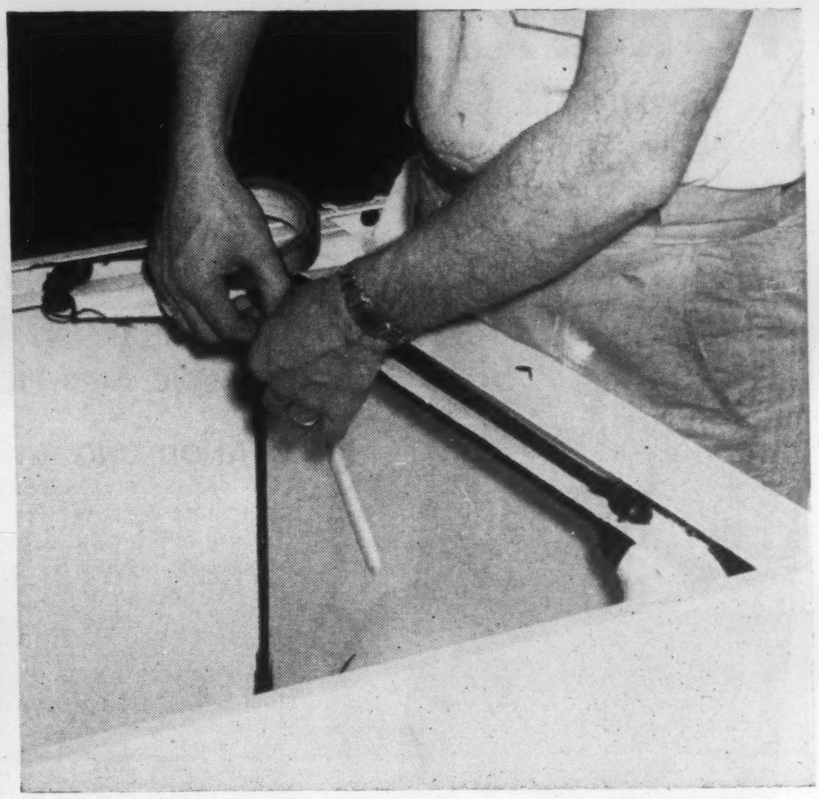

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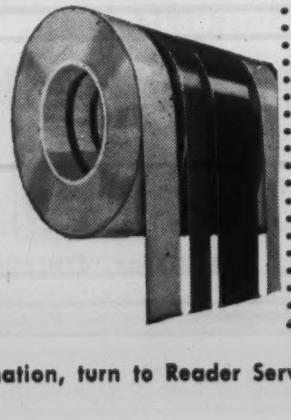

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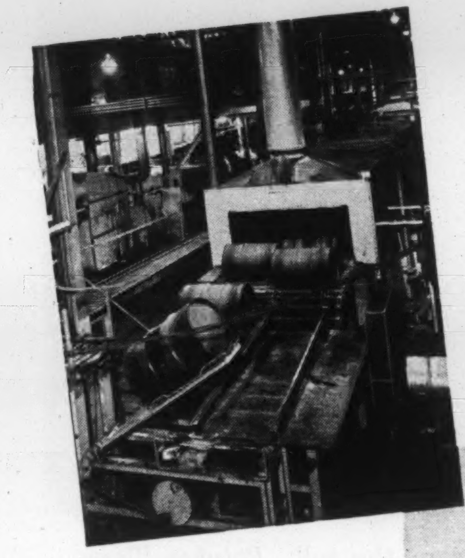

❶ **ALKALI CLEANING** removes oil, grease, fingerprints, hand-marks, other surface soil;
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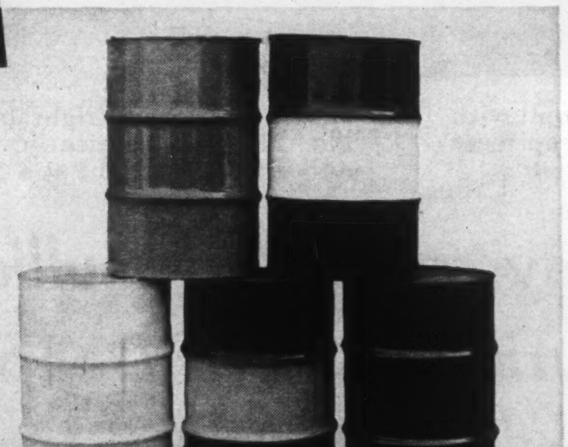

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signers, construction engineers and metallurgists concerned with the effect of stresses on structural performance.

Engineering Analysis. *D. W. Ver Planck and B. R. Teare, Jr. John Wiley & Sons, Inc., New York, N. Y., 1954. Cloth, 6 by 9 in. 344 pp. Price $6.00.*

This book is written as an aid in the teaching of courses in engineering analysis. The authors show what must be done to translate engineering situations into mathematical language and what is necessary after a mathematical result has been obtained. The book takes up such matters as: defining the problem to be solved, deciding what principle to apply, choosing coordinate systems, checking thoroughly, choosing dimensionless variables, and the sketching of curves. Topics discussed include material from dynamics of translation and rotation, electric circuits, heat transfer, solution of linear differential equations with constant coefficients, uses of power series, integration by graphical and numerical methods, hyperbolic functions, and the evaluation of indeterminate forms.

Industrial Diamond Trade Names Index, 5th Edition. *Compiled jointly by Industrial Diamond Information Bureau and Industrial Diamond Review. N. A. G. Press Ltd., London, England, 1954. Paper, 5½ by 8 in. 124 pp. Price 50¢.*

This index has been thoroughly revised and now contains about 2500 trade names. A data sheet supplement gives information on a number of subjects to users and producers of diamond tools; and the physical and chemical properties of diamond, the crystallography of diamond and the care of diamond truing tools, shaped diamond tools, glaziers diamonds, are also covered. Further, a list of diamond tool standards as established in England and other countries is given as well as a comparison of fine sieve sizes.

The Microscopy of Metals. *Institution of Metallurgists, London, England, 1954. Paper, 5½ by 8 in. 132 pp. Price $2.20.*

This publication contains the lectures delivered at the Refresher Course held in 1953. Papers include: Microscopes and Microscopic Techniques, G. K. T. Conn; General Metallography, H. Evans; The Use of Polarized Light in Metallography,

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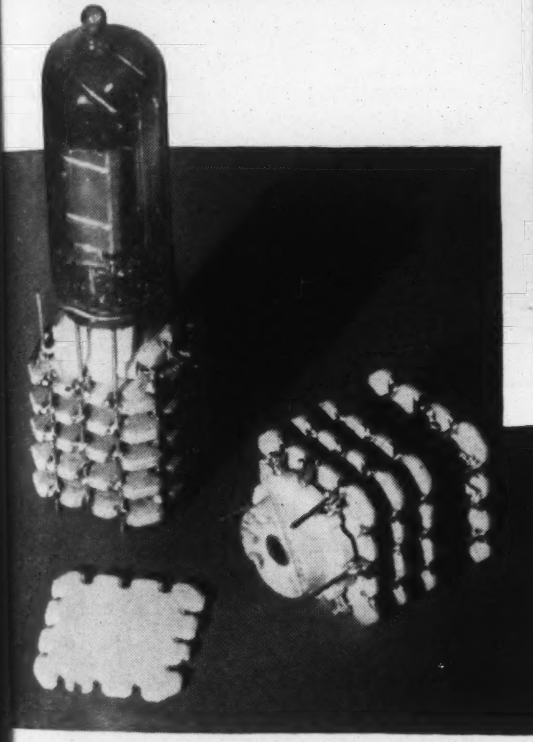

On Project Tinkertoy, ceramic wafers containing barium titanates are fired at 2600°F. The ℞ for this job is setter plates of Norton FUSED STABILIZED ZIRCONIA. These plates *engineered* to withstand the effects of the very reactive titanates and to make repeated trips to the electric furnace for 9-hour firing cycles — have proved to be most practical for firing titanates.

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The Norton ℞ For Tinkertoy

Firing of the Tinkertoy ceramic wafers — in electric furnaces at 2600°F — is an important processing step. For firing wafers containing barium titanate elements, the refractory setter plates selected are made of Norton FUSED STABILIZED ZIRCONIA.

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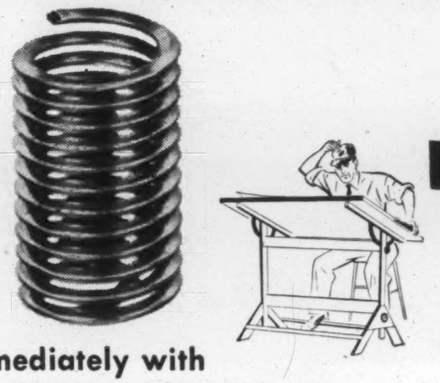

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B. W. Mott; Hot Stage Microscopy, P. J. E. Forsyth; and Phase-Contrast and Interference Metallography, D. McClean.

Applied Atomic Energy. *K. Fearnside, E. W. Jones and E. N. Shaw. Philosophical Library, New York, N. Y., 1954. Cloth, 5 by 7½ in. 156 pp. Price $4.75.*

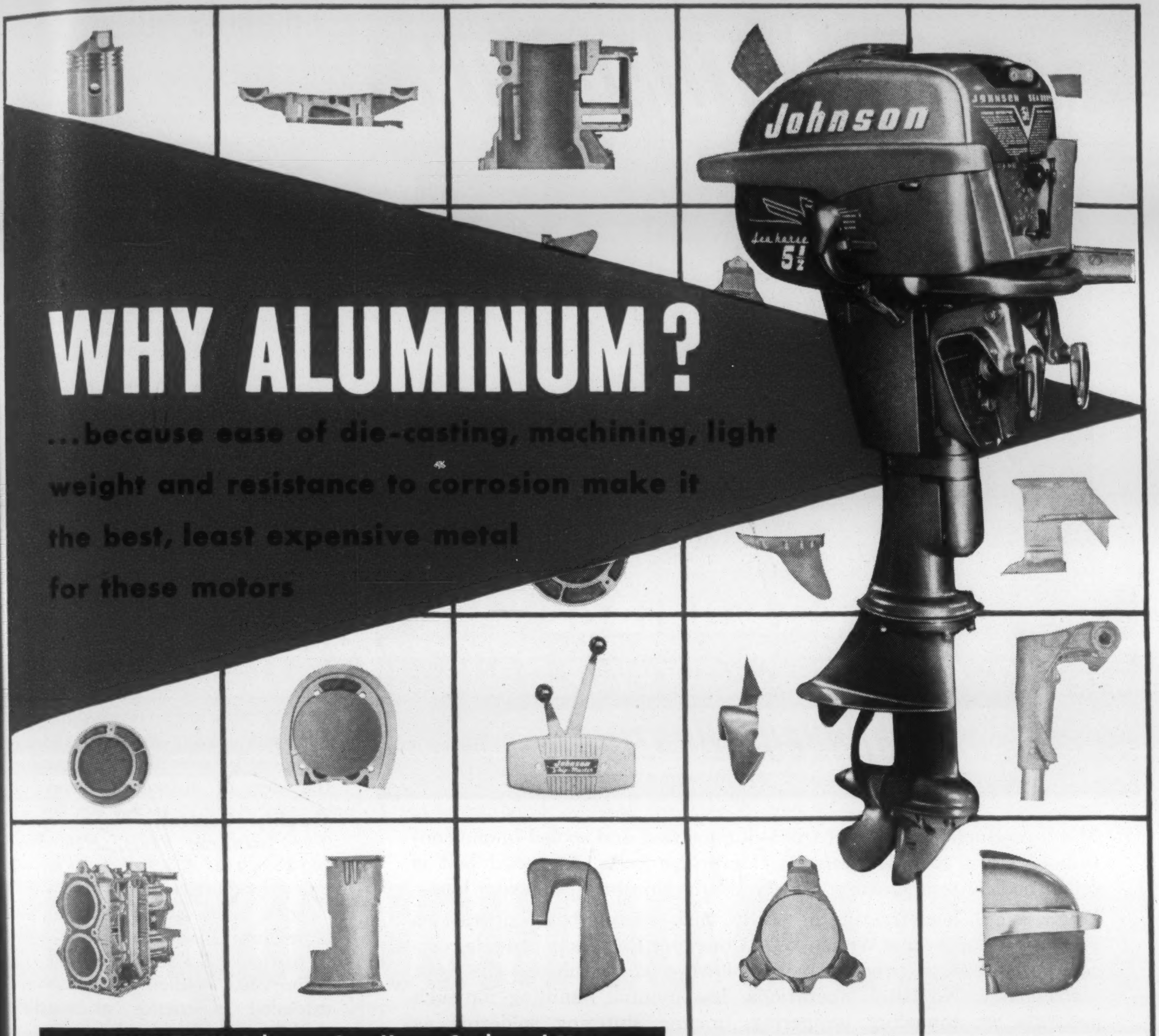
This book provides background knowledge of nuclear physics necessary to an understanding of the advantages to be derived from the application of atomic energy to peaceful purposes, in the shape of radioactive isotopes. Also discussed are a large number of applications to different fields of pure and applied science, including radiography techniques and the use of isotopes in pure research, in biological work, industrially, for medical purposes, etc.

Increased Production Reduced Costs Through A Better Understanding of the Machining Process and Control of Materials, Tools and Machines, Vol. 3. *James Van Voast. Curtiss-Wright Corp. Wood Ridge, N. J., 1954. Cloth, 7 by 10 in. 153 pp. No charge.*

Beginning with a refresher chapter on the practical principles of metal-cutting, the author proceeds to familiarize the reader with titanium by a brief account of the refining and mining of the metal, its properties, and a discussion of metallography. Subsequent chapters include such information on machining and grinding titanium as: turning, milling, routing, drilling, tapping, abrasive cutting, hacksawing, belt grinding, surface grinding, and machining high-temperature jet-engine alloys.

ASME Handbook Metals Properties. *Edited by Samuel Hoyt. Sponsored by the Metals Engineering Handbook Board of the American Society of Mechanical Engineers. Published by McGraw-Hill Book Co., New York, N. Y., 1954. Cloth, 7½ by 10 in. 439 pp. Price $11.00.*

Specific information for the designer about the properties of the metals with which he works—strength, hardness, machinability, electrical conductivity, etc.—is compiled in this valuable reference. The book, in convenient chart and table form, contains data on more than 500 metals in common industrial use—AISI steels, ASTM steels, cast



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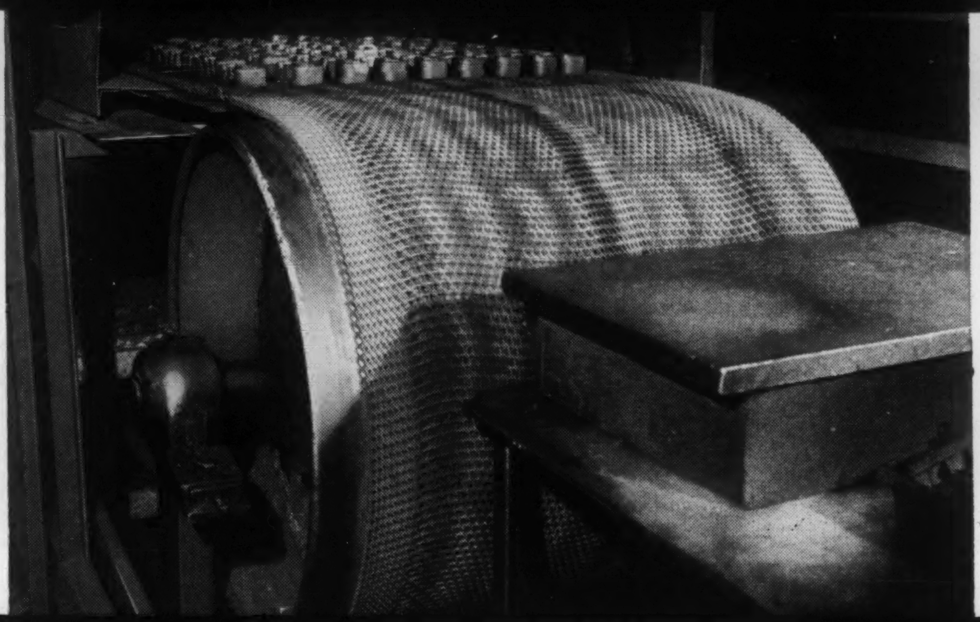

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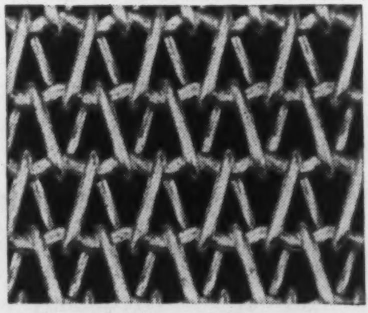

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Contents Noted

Books continued

copper alloys, aluminum alloys, tin, magnesium, etc. Tabulated under each of the metals listed is such information as the chemical composition of the metal, its brittleness, heat treatment and other characteristics, its industrial uses, treatment temperatures for forging, annealing, quenching, such technological properties as recrystallization temperature and hot working temperature.

The Structure of Metals and Alloys. *William Hume-Rothery and G. V. Raynor. The Institute of Metals, London, England, 1954. Cloth, 5½ by 8 in. 370 pp. Price $5.50.*

First published in 1936, this volume has been completely revised and brought up to date with considerable expansion of the material dealing with solid solutions and intermediate phases in alloys. New sections have been written on ternary alloys and on alloys of iron, while the part dealing with imperfections in crystals has been greatly extended and now includes a comprehensive account of the ideas of dislocation theory.

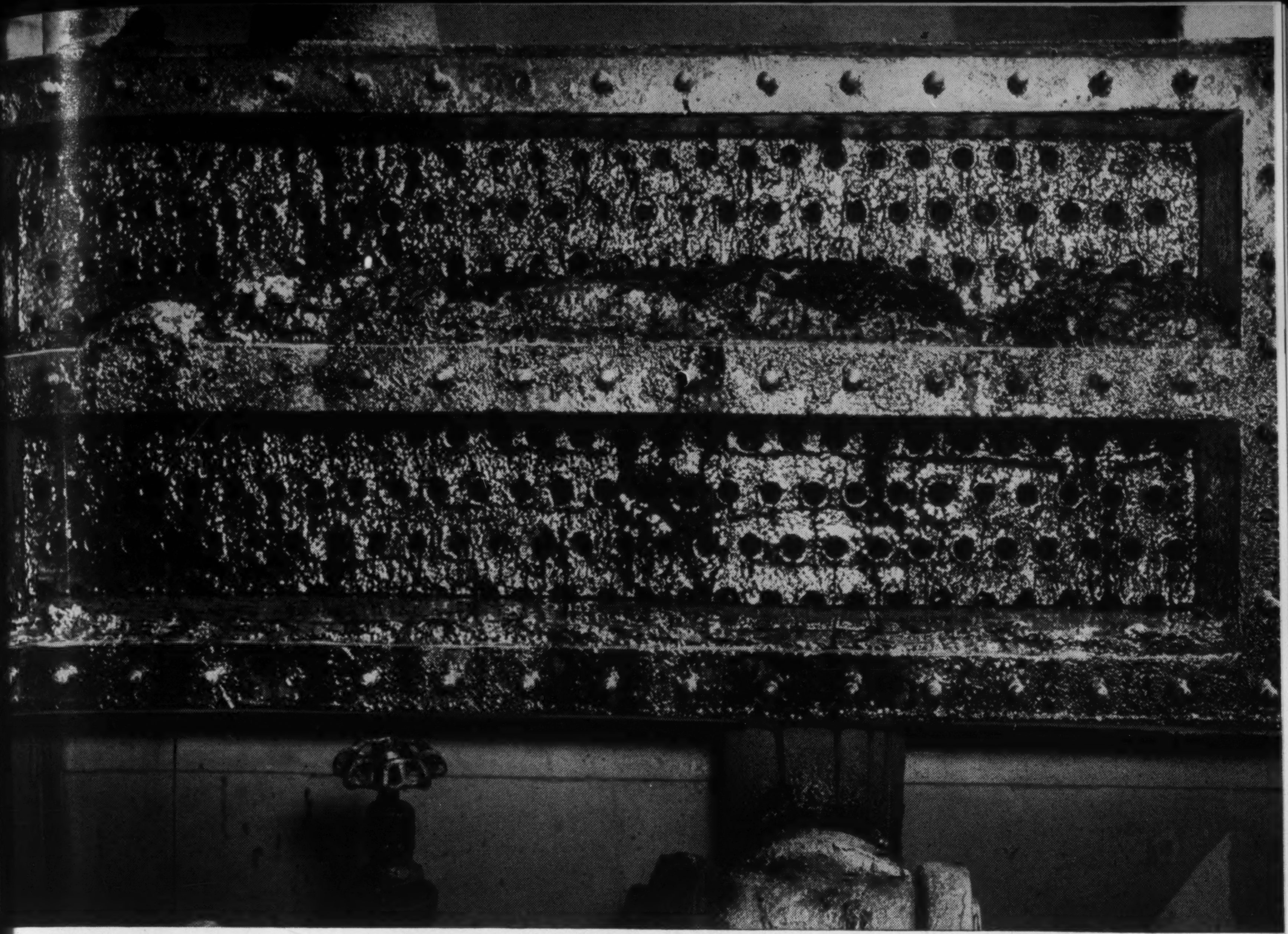
Quality Control. *N. L. Enrick. The Industrial Press, New York, N. Y., 1954. Cloth, 6 by 9 in. 181 pp. Price $4.00.*

Some sixty pages of new text, tables and charts have been added to this enlarged second edition. The author has written from his own extended experience in installing quality control procedures in more than thirty manufacturing plants and in teaching both college and industrial training courses. With an emphasis in clarity and simplicity of methods, the book deals with such topics as: ready made sampling plans, sample control charts, compressed limit gages, basis of proper specifications, separate theoretical chapters.

Reports

Adhesive Bonding Development of Metal-Bonding Adhesives with Improved Heat-Resistant Properties. *John M. Black and R. F. Blomquist, Forest Products Laboratory, May 1954. NACA RM 54D01, 12 pp, 3 tables. Available from the National Advisory Committee for Aeronautics, 1724 "F" St., N.W., Wash. 25, D.C.*
Report details results of work on de-

(Continued on page 176)



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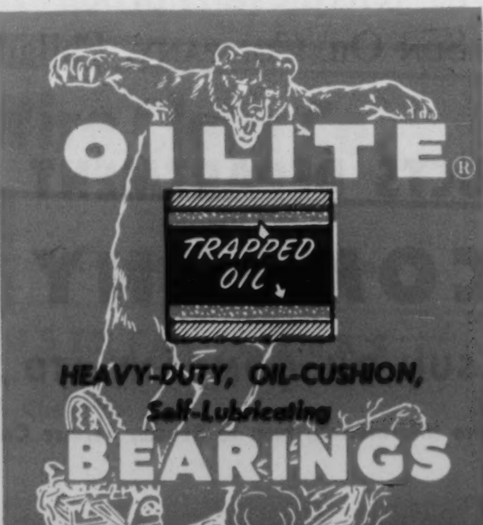

Contents Noted

Report
continue

velopment of metal bonding adh
sives with increased resistance
temperatures up to 600 F.

Brazing of Sintered Molybdenu
Evaluation of Alloys for Vacuu
Brazing of Sintered Wrought Moly
denum for Elevated-Temperatu
Applications. *Kenneth C. Dike, M*
1954. NACA TN 3148, 13 pp, di
grams, photographs, 2 tables. Ava
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Committee for Aeronautics, 17
"F" St., N.W., Wash. 25, D.
Brazing charactertistics were esta
lished in vacuum for 28 hr, liquid
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range. Tensile strengths of bu
brazed molybdenum joints of 10
the alloys range from 21,000 to 4
000 lb psi at room temperature a
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were heated in vacuum for 24 hr
1800 F to determine the effect
tensile strength. This treatment lo
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siderably but did not seem to aff
the 84% nickel-16% titanium
52% niobium-48% nickel a
bonds.

Adhesives vs Rivets Tests
Bonded and Riveted Sheet-Strin
Panels. *Leonard Mordfin and L*
Wilks, National Bureau of Sta
ards, June 1954. NACA TN 3
45 pp, diagrams, photographs, 5
bles. Available from the Nati
Advisory Committee for Aerona
1724 "F" St., N.W., Wash. 25, D
Report details results of bending
compression tests performed on
sheet-stringer panels of 75S-T6
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panels were bonded with adhes
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blies, since no great superiorit
one type of construction was p
over the other.

Hard Surface for Aluminum S
of Hard Coating for Aluminum
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Faster . . . Less distortion . . . Closer depth control . . . Selective heating . . . Reheating operation eliminated . . . No "oxygenation" of the case . . . Carburizing can easily be combined with martempering or brazing.

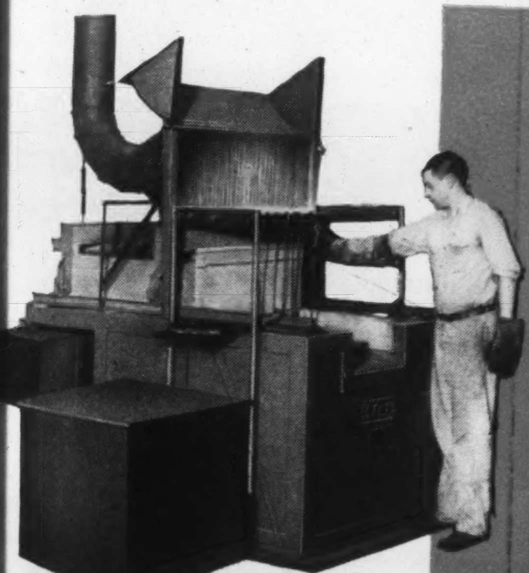
HARDENING
Complete protection of work against pitting, scaling, carburizing or decarburizing . . . Heating cycles 4 to 6 times faster . . . Low operating and maintenance costs . . . First cost of equipment materially less.

ALUMINUM HEAT TREATING
More production in less time . . . Faster, more uniform heating . . . Simplified quenching . . . Minimum warpage . . . Real protection to product by molten salt . . . Clean . . . No skilled labor needed.

PROCESS ANNEALING
No scale, decarburization or other surface effects . . . Annealing cycles reduced from hours to minutes . . . Great savings in floor space . . . 50% lower first cost of equipment.

CYANIDING
Large production in less space from smaller equipment . . . Minimum distortion . . . Higher and more uniform surface hardness of the finished product assures superior impact fatigue life.

CLEANING—DESCALING
Handles more work with less labor . . . Less floor space . . . Less time . . . Different metals and shapes can be cleaned or descaled simultaneously . . . Uniform cleaning does not affect base metal.



SAVE WITH SALT BATH HEAT TREATING!

Note these typical advantages

MARTEMPERING and AUSTEMPERING
No oil quenches required . . . Negligible distortion cuts costs by permitting machine finishing before hardening . . . Scale, decarb and quench cracks eliminated . . . Toughness and ductility are increased.

BRAZING
Work can be immersed in batches for maximum speed and economy . . . All joints brazed simultaneously in seconds . . . No decarburization of steel assemblies . . . No cooling chamber needed . . . Can be simply combined with carburizing or hardening.

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FURNACES

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x Engineering Corp., Ajax Electrothermic Corp.

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ELECTRIC SALT BATH FURNACES
World's largest manufacturer of electric heat-treating furnaces exclusively

For more information, turn to Reader Service Card, Circle No. 321

ANNEALING ALUMINUM STRIP IN CONTROLLED ATMOSPHERE

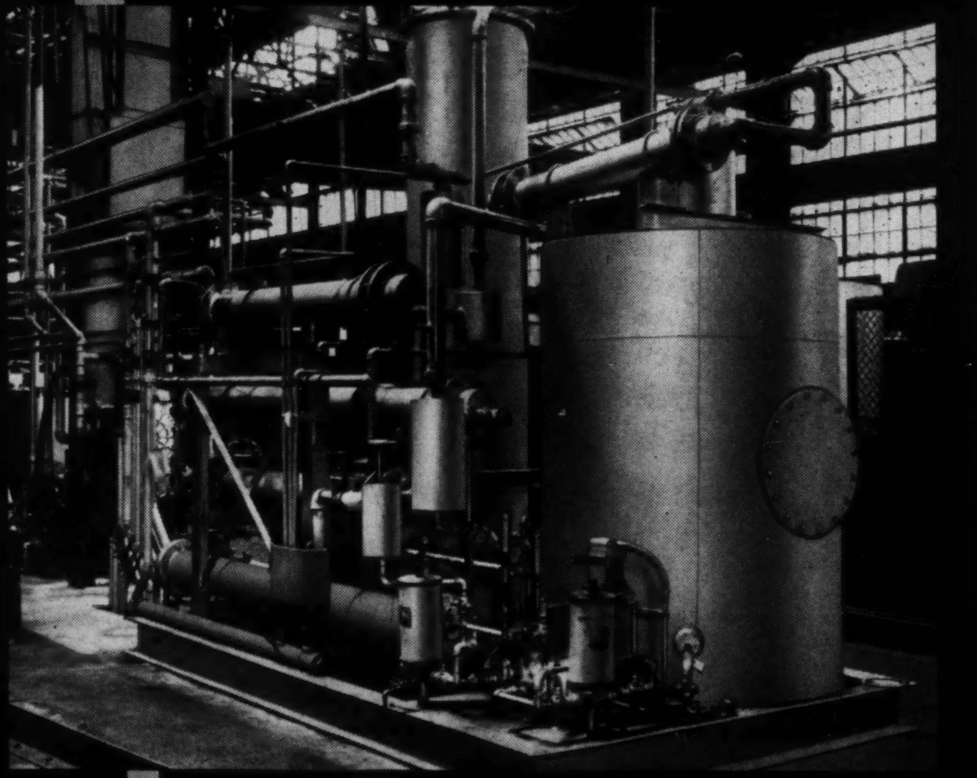
Scovill Manufacturing Co. Selects GAS ATMOSPHERES' GENERATORS To Produce Stain-Free Strip

The Scovill Manufacturing Company of Waterbury, Conn., long a leader in producing quality copper-base alloy strip, recently put the finishing touches to the first production installation of a controlled atmosphere aluminum strip annealing system.

This new system enables Scovill to produce controlled grain sizes, tempers, directional properties and dimensions in aluminum strip far closer than was once thought possible. And, by annealing in a controlled nitrogen atmosphere, the strip retains its original brightness.

To get the purest atmosphere in the shortest possible time Scovill selected a Gas Atmospheres' Nitrogen Generator which has since delivered extraordinary production economy ratios while requiring no more than initial adjustment.

Gas Atmospheres has long been a supplier of compact generators for producing any quantities of controlled annealing atmosphere gases at exceptionally low cost. So when next considering generated atmosphere remember it will pay you to consult Gas Atmospheres before you buy. Representatives in leading metal producing areas.



gas Atmospheres, inc
equipment for producing industrial gases
20011 WEST LAKE ROAD CLEVELAND 16, OHIO

For more information, turn to Reader Service Card, Circle No. 350

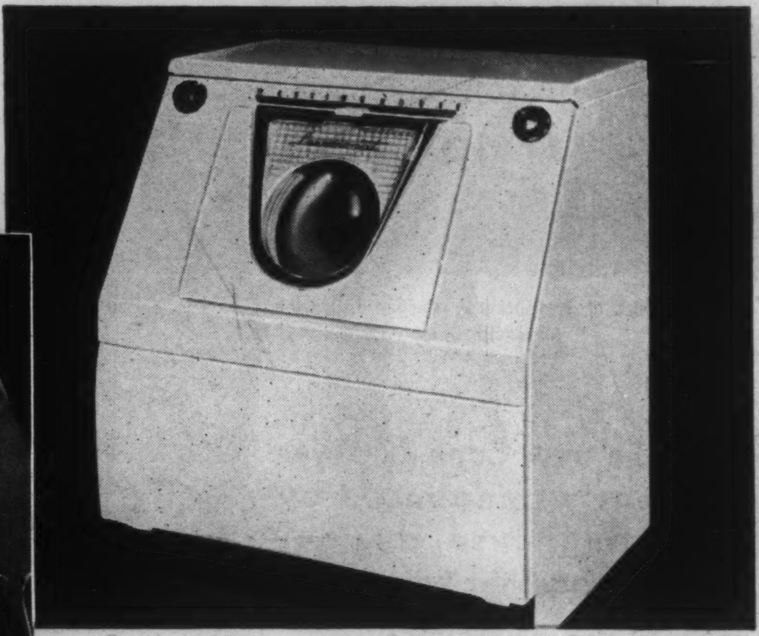
nical Services, Wash. 25, D.C. $2.00. Report details results of tests on five wrought and two cast aluminum alloys by the Martin Hard Coat process. Hard oxide coatings ranged in thickness from 0.0005 to 0.005 in. Wear resistance is reported far above that given by standard anodizing treatments and is equal to, or better than, that of thin cyanide coatings on steel. Reductions in fatigue strength in the base metal of up to 65% indicate that the process is not suitable in applications subject to cyclic stresses.

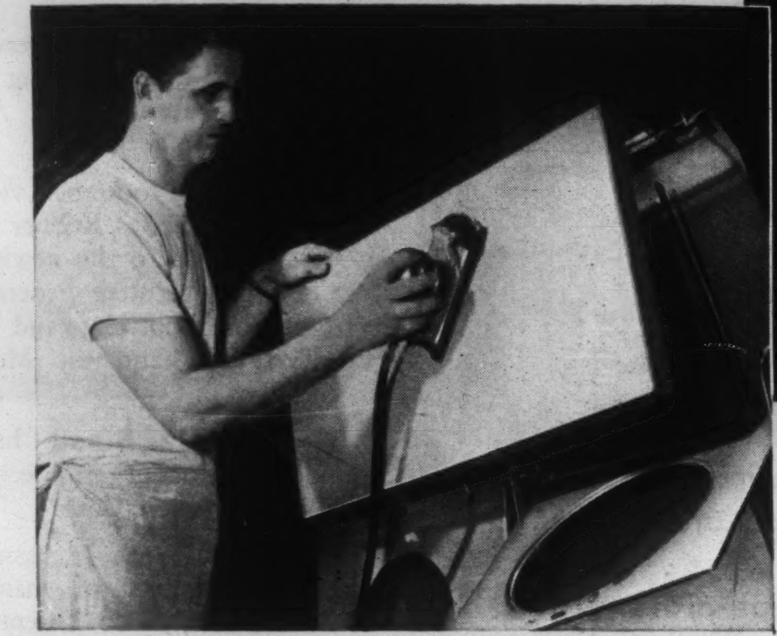
Glass Fiber Papers Electrical Properties of Glass Fiber Papers. *Naval Research Laboratory. PB 111310, 27 pp. Available from U.S. Department of Commerce, Business and Defense Services Administration, Attn. Office of Technical Services, Wash. 25, D.C., $.75.* Report discusses research undertaken to encourage quantity industrial production of superfine glass fibers for use in filter papers, dielectric papers, and non-flammable products. Produced successfully where silica fibers have thermal stability in excess of 2732 F, copper bearing fibers, fiber suitable for protective shields against radiation, and toxicological glasses for fungus-resistant papers. Included are descriptions of methods for reducing production costs and increasing yield.

Flash Sintering of Cermets Production of Cermets by Flash Sintering Process. *PB 111286, 69 pp. Available from U.S. Department of Commerce, Business and Defense Services Administration, Attn. Office of Technical Services, Wash. 25, D.C. $2.00.* Report includes historical background, description of equipment, and discussion of test results on the flash sintering process for producing turbo-jet engine blades and other temperature-resistant components. Flash, or electric resistance, sintering involves the rapid heating of metal powder mixtures by direct passage of high amperage current with a simultaneous application of high pressure on the die. Details of compact preparation and pre-sintering processes are given, as well as the most favorable conditions of powder influx, time and pressure for producing nickel-titanium carbide compacts of optimum physical characteristics.

EPON® RESIN does it!

WESTINGHOUSE Laundromat gets a tougher, more corrosion-resistant primer at much lower cost!





Laundromat has a baked Epon, flow-coated primer formulated by Pittsburgh Plate Glass Company. Film uniformity calls for only the briefest scuff sanding before application of the white enamel top-coat.

HERE'S HOW...

The protective finish on a washing machine is exposed to severe conditions during its service life. It must, for example, withstand abrasion, impact, attack from highly active alkalies and detergents.

Recently, Westinghouse engineers adopted a greatly improved finish for Laundromat components, using a new *primer* based on Epon resin. Applied by flow coating, the primer is only one-third the thickness of previously used primers. Tests have established a *three-fold* improvement in coating durability under severe conditions . . . and application costs have been materially reduced.

Laundromat components receiving the new Epon resin primer are: top, front, door, lower front panel, bracings, clamps and bottom pan. Some interior surfaces have *Epon primer as their only finish.*

If you need a protective finish like this in your paint program, ask your supplier for Epon resin-based paints and enamels. These formulations have excellent adhesion, high resistance to impact and abrasion; outstanding resistance to moisture, heat and corrosive atmospheres.

• • •

Write for the brochure "Planning to Paint a Pyramid?" on the variety of applications of Epon resins in surface coatings. You may call on our sales offices for names of manufacturers who sell Epon resin coatings.

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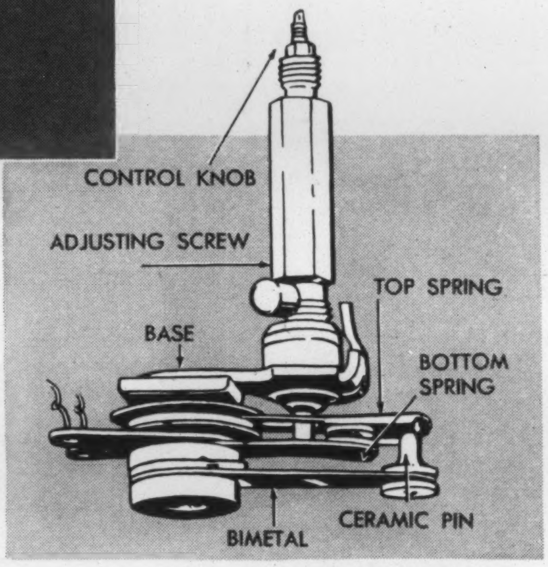
For more information, turn to Reader Service Card, Circle No. 455

HOW CHACE THERMOSTATIC BIMETAL ACTUATES and CONTROLS THE Westinghouse Cook-N-Fryer

A Product of Westinghouse Appliance Division
Mansfield, Ohio



The new Cook-N-Fryer recently announced by Westinghouse, demonstrates another typical use of Chace Thermostatic Bimetal for actuating and controlling cooking appliances. The thermostat is the well-known Unitherm, variations of which are used in a number of Westinghouse Appliances.

The operating principle is reliable and time-proven. The control knob is mounted on the hexagonal shaft in a horizontal position. When the knob is set to the desired temperature, the thermostat top spring is a fixed distance from the bimetal pin. As the appliance heats, the bimetal element deflects upward until the ceramic pin engages the top spring and opens the circuit. Cooling then begins, the thermostat re-closes and once again the appliance begins to heat. It is this successive heating and cooling of the thermostat and the subsequent opening and closing of the appliance heating circuit that maintains the Westinghouse Cook-N-Fryer at the proper cooking temperature.

Manufacturers of heat responsive devices all over the country are specifying Chace Thermostatic Bimetal for control, indication and protection of costly equipment. We furnish our 29 types in strip, random length rolls or in completely fabricated elements or assemblies to your specification. Write today for your copy of "Successful Applications of Chace Thermostatic Bimetal", a handbook of engineering data. Or call on our application engineers before proceeding with your new design.

W. M. CHACE CO.
Thermostatic Bimetal
1615 BEARD AVE., DETROIT 9, MICH.

For more information, turn to Reader Service Card, Circle No. 431

news of ENGINEERS COMPANIES SOCIETIES

News of Engineers

Ellison L. Hazard has been named general manager, North Eastern district, Eastern Metal Div., Continental Can Co.

H. Leon Moran has been appointed new products manager for the Mechanical Goods Div., United States Rubber Co.

W. D. Holland has been named manager of manufacturing for the Plastics and Resins Div., American Cyanamid Co.

Chester J. Noonan, vice president, United States Rubber Co., has been appointed to the newly-created position of executive general manager of the Footwear and General Products Div. and the Mechanical Goods Div.

Warren H. Brand has been named director of engineering and research, Conoflow Corp.

Frank R. Grote Jr., assistant to the superintendent of manufacture in American Can Co.'s Central Div. office, has been named superintendent of the firm's new Denver plant.

S. H. Newburn has been appointed president of Air Reduction Canada Ltd.

Austin E. Fribance has been named chief engineer of the Rochester Manufacturing Co. and in that capacity will have charge of product design, and of research and development.

Stanley C. Amren has joined Cleveland Welding Co., subsidiary of American Machine & Foundry Co., as vice president and general manager.

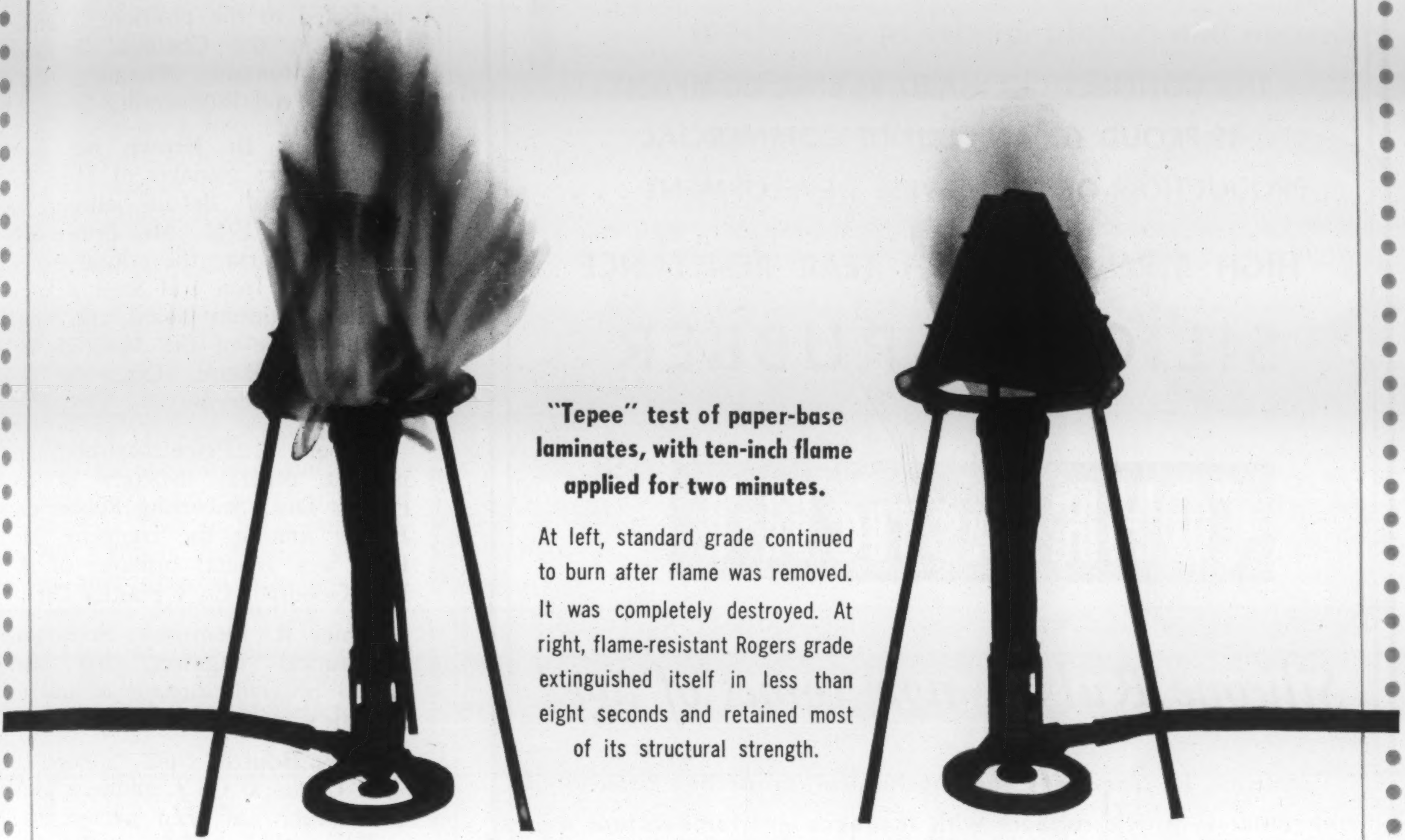
S. K. Derderian has been appointed general manager of Metal Hydrides, Inc.

Fenmore E. Dunn has been appointed general manager of Worthington Corp's reorganized Vertical Turbine Pump Div.

Ernest E. George, manager of design and application engineering, Carboloy Dept. of General Electric Co., has been named manager of magnetic products engineering.

(Continued on page 182)

another ROGERS innovation



"Tepee" test of paper-base laminates, with ten-inch flame applied for two minutes.

At left, standard grade continued to burn after flame was removed. It was completely destroyed. At right, flame-resistant Rogers grade extinguished itself in less than eight seconds and retained most of its structural strength.

WORK-HORSE MATERIALS MADE FLAME-RESISTANT

BY WORK-HORSE, we mean our paper-base laminates, which are now available with exceptional flame-resistant qualities. The main purpose of these materials is to reduce costs in applications that now require glass-base laminates.

We have also added flame-retardant properties of our DUROID 800, a fibrous insulating material, listed by Underwriters' Laboratories as suitable for the sole support of current carrying parts. DUROID 800 is also self-extinguishing, but will not withstand as severe burning as our flame-resistant laminates.

Since industry-wide specifications for flame-resistant or flame-retardant materials do not exist, each of these Rogers materials should be assessed in terms of your application. Complete data are available, and we will be glad to supply samples for your own testing purposes.

Please write Dept. M, Rogers Corporation, Rogers, Connecticut.

Better Parts for Better Products

INFORMATION WITH A LIGHT TOUCH . . . Please write for "Here's Rogers Again." It will help you appraise our company's place in your plans — at seconds-per-page speed.

REINFORCED CHEMICALS

Rogers specializes in combining fibers and chemicals to produce Fiberloys that meet special material requirements. We welcome problems that existing materials can't solve.

ROGERS CORPORATION
ROGERS, CONNECTICUT

For more information, turn to Reader Service Card, Circle No. 415

Announcement

THE CONNECTICUT HARD RUBBER COMPANY
IS PROUD TO ANNOUNCE COMMERCIAL
PRODUCTION OF ITS NEWEST DEVELOPMENT . . .

HIGH STRENGTH, HIGH TEAR RESISTANCE
SILICONE RUBBER

COHRlastic H-T ®*

Silicone Rubber now comes of age!

Cohrlastic HT combines the mechanical properties associated with other synthetic rubbers with the excellent temperature and electrical characteristics of the silicones.

This development, made by our chemists and engineers, is so outstanding that many users of rubber will wish to investigate its application to their specific problems. The properties now available in COHRlastic HT are:

HIGH TENSILE STRENGTH — *up to 2,000 pounds*
HIGH TEAR RESISTANCE — *equal to most rubber compounds*
HIGH ELONGATION — *up to 600 percent*
EXTREME LOW TEMPERATURE RESISTANCE
RESISTANCE TO MANY CHEMICALS AND SOLUTIONS
EXCELLENT ELECTRICAL PROPERTIES
EXCELLENT OZONE AND OXIDATION RESISTANCE

FURTHER DETAILS ON REQUEST — WRITE TO

Connecticut
HARD RUBBER COMPANY
419 EAST STREET, NEW HAVEN, CONNECTICUT

®Trade-mark registered
*Patents applied for

For more information, turn to Reader Service Card, Circle No. 430

news of | ENGINEERS

Dr. William T. Cave has been promoted to the position of group leader in the Chemical Research Dept., Monsanto Chemical Co.'s Research and Engineering Div.

Graham B. Brown has been named works manager of Tube Reducing Corp. Before joining the company in 1951, Mr. Brown was employed during the critical period 1948-51 as Iron and Steel Advisor to the Munitions Board, and Chief of the Office of the Materials Requirements Board, Office of the Secretary of Defense.

Robert S. Price has been appointed general manager of the Plastics Div., Seiberling Rubber Co. Before joining the company, Mr. Price was general manager of the B.F. Goodrich Co.'s Plastics Div.

James R. Dempsey, electronics-aeronautical engineer, has been named program director of one of Convair's guided missile projects.

C. P. Boutte, chief engineer at Shell Chemical Co.'s ammonia plant in Ventura has been named chief engineer at Norco. **G. A. Daniels,** senior engineer at Ventura, will succeed Mr. Boutte.

Nolan E. McDonald, formerly technical assistant to the chief engineer of Reynolds Metals Co., has been named to head the new Impact Extrusion Dept., Magnesium Co. of America.

Semon H. Stupakoff, formerly president of Stupakoff Ceramic and Manufacturing Co., was elected vice president of the Carborundum Co. As vice president of the company, Mr. Stupakoff will continue to direct the activities of the Stupakoff Div. of Caborundum.

Robert W. Kerr, formerly deputy group executive of American Machine & Foundry Co.'s General Products Group, has been named a divisional vice president and group executive of AMF's General Products Group.

Harry S. Brenner has been appointed director of engineering for the Olympic Screw & Rivet Corp.

Donald B. Benedict has been named works manager of Carbide and Carbon Chemicals Co., a Division of Union Carbide and Carbon Corp.

Stanley W. Lovejoy has been appointed to the position of manager,

news of ENGINEERS

cutting tool research, Pratt & Whitney, Division Niles-Bement-Pond Co.

Carey H. Brown, manager of engineering and manufacturing service at Kodak Part, Eastman Kodak Co., has announced his retirement after twenty years with the company. Mr. Brown expects to spend much of his time in the next year with the Task Force on Water Resources and Power for the Hoover Commission.

Joseph F. Chalupa has been appointed assistant works manager of the Aviation Gas Turbine Div., Westinghouse Electric Corp.

Norman J. Cyphers has been named director of research and development of Boston Woven Hose & Rubber Co. Prior to his appointment Mr. Cyphers had been vice president and technical director of Acme-Hamilton Manufacturing Co.

T. C. Gray has been elected vice president in charge of engineering, Pullman-Standard Car Manufacturing Co.

H. W. Hundley, manager of National Lead Co.'s Cincinnati Branch since 1943, has retired after 47 years with the company. **S. R. Hollingsworth** becomes manager of the Metal Div. of the branch; **C. J. Surman,** manager of the Paint Div., and **W. W. Howard,** manager, Pigments Div.

Leo A. Schmidt, specialist in fluid dynamics, has been named supervisor of the Aerodynamics and Compressible Flow Section, Propulsion and Structural Research Dept., Armour Research Foundation, Illinois Institute of Technology.

Reid W. Malcolm, Jr. has been appointed director of research and development of the R.M. Hollingshead Corp.

Clyde M. Adams, secretary of the Bohn Aluminum & Brass Corp., has been appointed director of the Aluminum and Magnesium Div., Business and Defense Services Administration of the Dept. of Commerce.

Allyn E. Harper has been appointed chief of the Mechanical Engineering Div., E. J. Longyear Co.

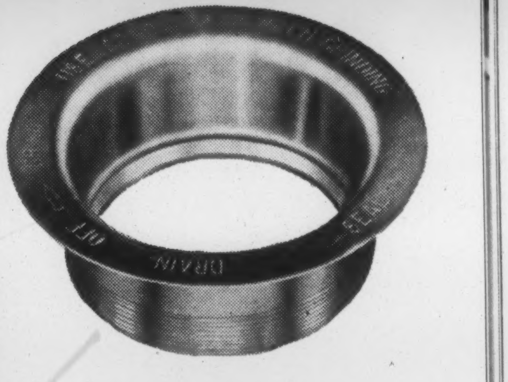
Joseph Mihalyi, superintendent of special development at Camera Works, Eastman Kodak Co., has announced his retirement after more than thirty years of service.

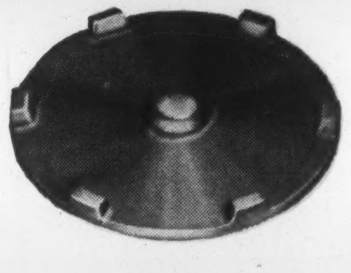
(News of Companies on page 184)

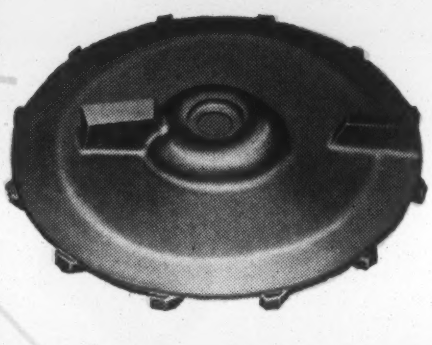
For more information, Circle No. 402 ➤

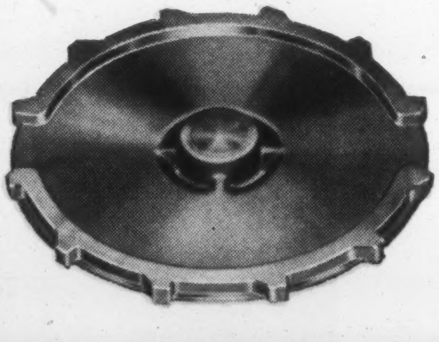
MUELLER BRASS CO. forgings* contribute to the efficiency of this modern waste disposal unit

***MUELLER BRASS CO. facilities include: designing, die-making, forging, tooling, machining, polishing, plating and assembly**









Three Mueller Brass Co. forgings play an important part in the fine operating performance of this modern waste disposal unit made by the Eureka-Williams Co., Division of the Henney Motor Co., Inc. This unit does a speedy and thoroughly effective job of pulverizing garbage and has made life easier for American housewives. The impeller disposer that chops up the waste food in the disposal unit, the disposer cover and the sink mounting flange are all forged by the Mueller Brass Co. This is another outstanding instance where Mueller Brass Co. forgings have improved product performance and cut costs. High quality forgings can be produced from standard and special brass, bronze and aluminum alloys. And in addition, the Mueller Brass Co. offers complete service ranging from product design to finished part . . . Write today for complete information and new 32 page forgings handbook.

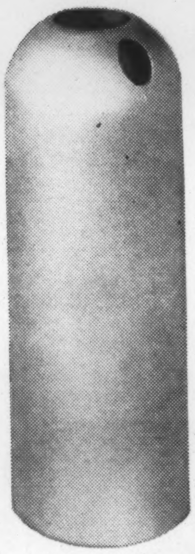
1. Sink mounting flange, forged, machined, nickel and chrome plated by Mueller Brass Co.
2. Machined and finished disposer cover forging.
3. Cutting side of impeller disposer forged from 600 series bearing bronze.
4. Reverse side of impeller disposer.

MUELLER BRASS CO.

PORT HURON 16, MICHIGAN

when your customers ask about

product appearance...



Show them the smoothly rounded contours of a Hackney Deep Drawn Part. Explain that the deep drawing process produces extra smooth surfaces—that minimum seam area results from this type of design.

These are some of the attractive features which other manufacturers have been able to design into their products by replacing a cast, forged or welded pipe part with a Hackney Deep Drawn Shape or Shell. If you are redesigning for better appearance, these Hackney features may help you.

In addition, Hackney Parts may increase product value through one or more of the following advantages:

Lower unit cost
Greater strength—Extra durability
Lower over-all weight—Closer tolerances
In sizes from one quart up to 150 gallons.

Write today for additional information.

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Manufacturer of Hackney Products
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241 Hanna Bldg., Cleveland 15
936 W. Peachtree St., N. W., Room 111, Atlanta 3
208 S. LaSalle St., Room 788, Chicago 4
559 Roosevelt Bldg., Los Angeles 17
18 W. 43rd St., Room 11, Kansas City 11, Mo.

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CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

For more information, turn to Reader Service Card, Circle No. 303

news of | COMPANIES

E. I. du Pont de Nemours & Co., Inc. will build a new research laboratory for its Film Dept. at its Experimental Station. The laboratory, representing an investment of $1,275,000, is scheduled for completion by the end of 1955.

Bigelow - Sanford Carpet Co., Inc. has acquired the assets of **LeConte Plastics Co., Inc.,** Farmingdale, N.Y. The LeConte Co. will become a division of Bigelow-Sanford's Special Products Div. Charles LeConte has been named general manager of Bigelow-Sanford's reinforced plastics operations.

Arthur D. Little, Inc. has acquired the Research and Development Division and Laboratories of the **Merrill Co.,** a metallurgy and engineering firm in San Francisco.

The Technical Div. of **Tracerlab, Inc.,** is sponsoring a Symposium on the Applications of Radioactivity in the Rubber and Plastics Industries to be held in Boston at the Sheraton-Plaza Hotel, Oct. 6-8.

Peter A. Frasse and Co., Inc., has announced its new appointment as a distributor of aluminum for the Reynolds Metals Co.

Laclede Steel Co. recently held a three-day open house at its Alton, Ill., plant where more than 20,000 persons received a first-hand view of steel-making operations.

National Lead Co. has been selected to operate the U.S. Atomic Energy Commission's Raw Materials Development Laboratory at Winchester, Mass., which has been operated by the American Cyanamid Co. under Commission contract since 1951.

Wheeling Steel Corp. will construct a second continous galvanizing line for the production of galvanized sheets and strip. This line, to be built at an estimated cost of $4,000,000, will be located at the company's Martins Ferry factory in Ohio.

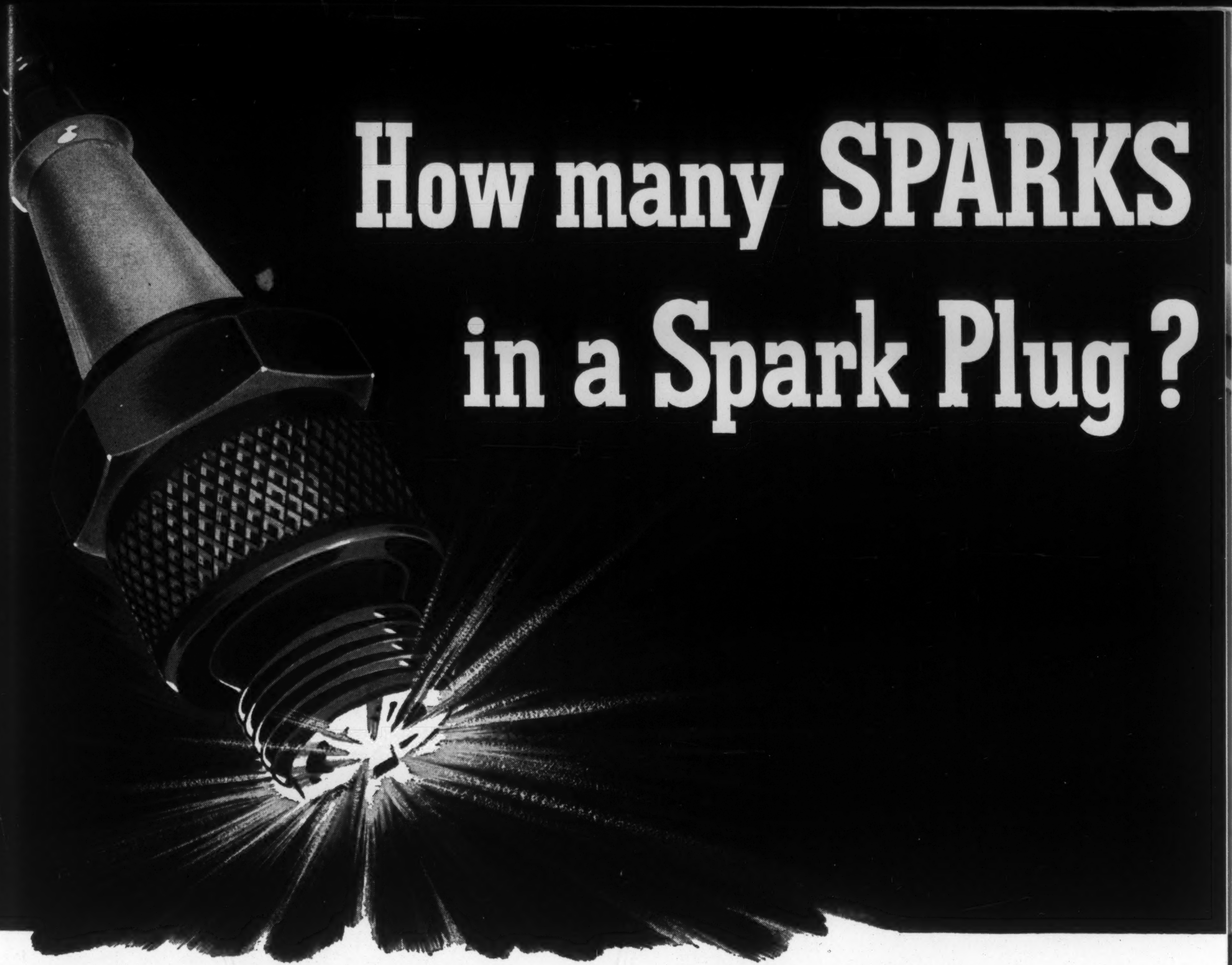
Interchemical Corp. has announced the establishment of a Product Application Engineering Dept. to be headed by F.L. Wurzburg, Jr.

Reynolds Metals Co. has announced a $2,585,000 program to expand and modernize aluminum sheet mill facilities at Sheffield, Ala.

Pioneer Electronics Corp. has announced an addition of 500-sq-ft to its plant.

(News of Societies on page 186)

How many SPARKS in a Spark Plug?



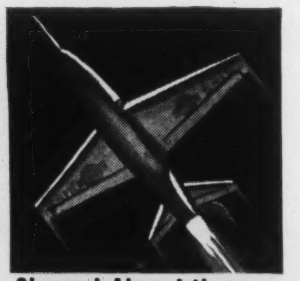
Surprising, the confidence that people have in spark plugs. No one stops to question how many "sparks" they're good for, because long-life performance has come to be taken for granted. Yet, when you get right down to it, you'll find good reasons for this complete consumer confidence. And, from a "sparking" point of view, perhaps the most important is the almost universal use of special Hoskins alloys for the vital electrode wires.

Producing the wire that sparks your car to power is a tough and tricky business. It requires special care in the selection of raw materials. Special melting and production techniques. Plus extremely close control over alloy composition and uniformity of quality throughout the entire manufacturing process.

Yet that's exactly the kind of alloy that Hoskins is qualified to produce best. For, among the other quality-controlled alloys developed and manufactured by Hoskins are: Alloy 717—for facing engine valves; Alloy 785—for brazing belts; Alloy 502—for countless heat resistant mechanical applications. Then, too, there are the Chromel-Alumel thermocouple alloys . . . guaranteed to register true temperature-EMF values within specified close limits. And, of course, Hoskins CHROMEL . . . the *original* nickel-chromium resistance alloy used as heating elements and cold resistors in countless different products.

Hot stuff for hot jobs! Hoskins Alloy 502 is ideally suited to many mechanical-structural applications.

Heating elements made of Hoskins Chromel deliver full-rated power throughout their long and useful life.



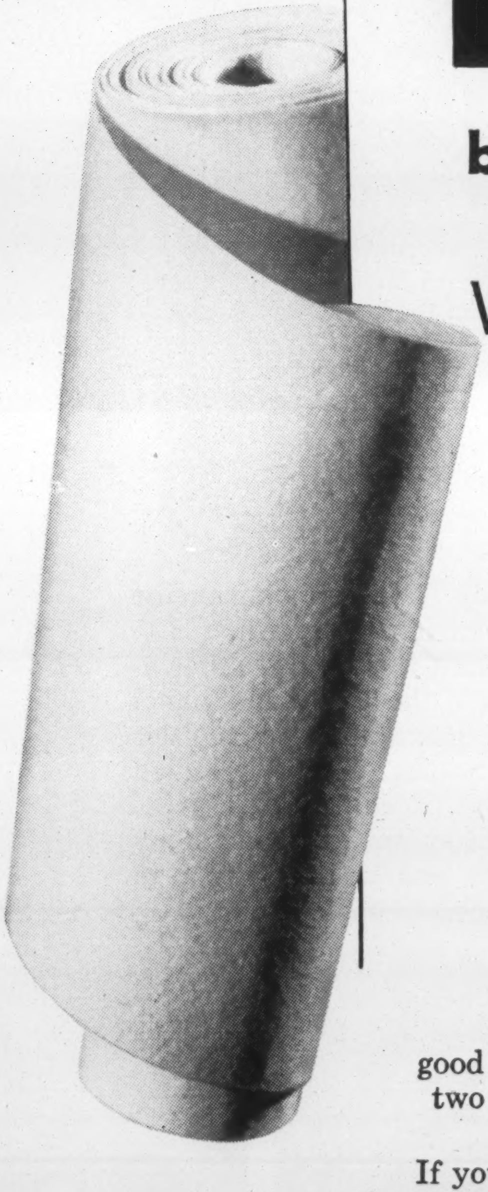
Chromel-Alumel thermocouple alloys accurately measure exhaust temperatures of jet aircraft engines.

Chromel®
NICKEL CHROMIUM WIRE

HOSKINS
MANUFACTURING COMPANY

4445 LAWTON AVENUE, DETROIT 8, MICHIGAN

For more information, turn to Reader Service Card, Circle No. 401



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Wicks
Packings
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Electrical appliances
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Shock absorbers
Vibration controls

(Your product goes here)

Resiliency that permits constant spring-back to original shape . . . and good absorptive characteristics . . . are just two of the many properties you can get in Felt made by Felters.

If you have a problem that could be solved by a soft, porous material, or by a hard, dense material — your answer could well be a Felt made by Felters.

The "Felters Design Book" describes several usual and unusual uses for Felt. Drop us a line and we will send you a copy.

HEARD ABOUT ***UNISORB®*** *— THE MODERN MACHINERY MOUNTING?*

The **FELTERS** Company
220 South Street, Boston 11, Mass.

For more information, turn to Reader Service Card, Circle No. 414

news of | SOCIETIES

The **Malleable Founders' Society** presented the 1954 award for outstanding service to the malleable iron castings industry to John A. Wagner, president, Wagner Malleable Iron Co. The award is presented annually in memory of Charles H. McCrea, former president of the National Malleable and Steel Castings Co. of Cleveland.

The **Society of the Plastics Industry, Inc.** re-elected John J. O'Connell, president, Consolidated Molded Products Corp., as its president.

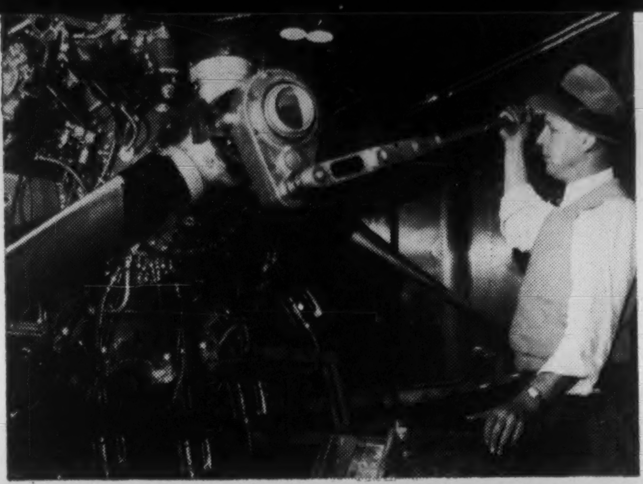
The **American Society for Testing Materials** elected the following officers at its recent meeting: Norman L. Mochel, manager, Metallurgical Engineering, Westinghouse Electric Corp., president and Rudolph A. Schatzel, vice president and director of engineering, Rome Cable Corp., vice president. Authors of outstanding technical papers published by the Society received awards at the meeting. The Charles B. Dudley Medal went to Clyde E. Work and Thomas J. Dolan, assistant professor and research professor, respectively, University of Illinois, for their paper, "The Influence of Strain-Rate and Temperature on the Strength and Ductility of Mild Steel in Torsion". The C. A. Hogentogler Award was received by A. A. Wagner, materials engineer, Bureau of Reclamation, for his paper, "Lateral Load Tests on Piles for Design Information". The Richard L. Templin Award was presented to E. T. Wessel and R. D. Ollman, metallurgical and Ceramic Dept., Westinghouse Electric Corp., for their paper, "Apparatus for Tension Testing at Subatmospheric Temperatures". The Sam Tour Award was received by John T. Richards, chief engineer, Penn Precision Products, Inc. for his paper, "The Corrosion of Beryllium Copper Strip in Sea Water and Marine Atmospheres".

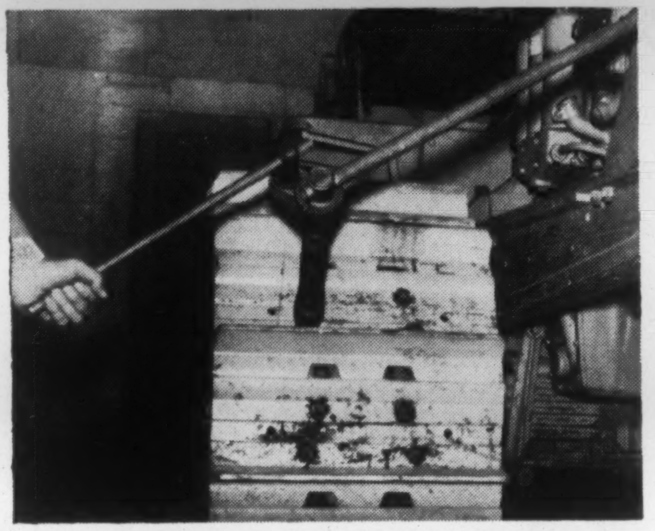
The **Cleveland Engineering Society** has reelected Ralph R. West, president of West Steel Casting Co., as its president for a second term.

The **Malleable Founders Society,** at its annual meeting, elected Charles E. Brust, president, Eastern Malleable Iron Co., as its president for the coming year. Carl L. Liebau, executive president and general manager, Federal Malleable Co., was elected vice president.

(Meetings & Expositions on page 188)

For more information, Circle No. 417 ➤





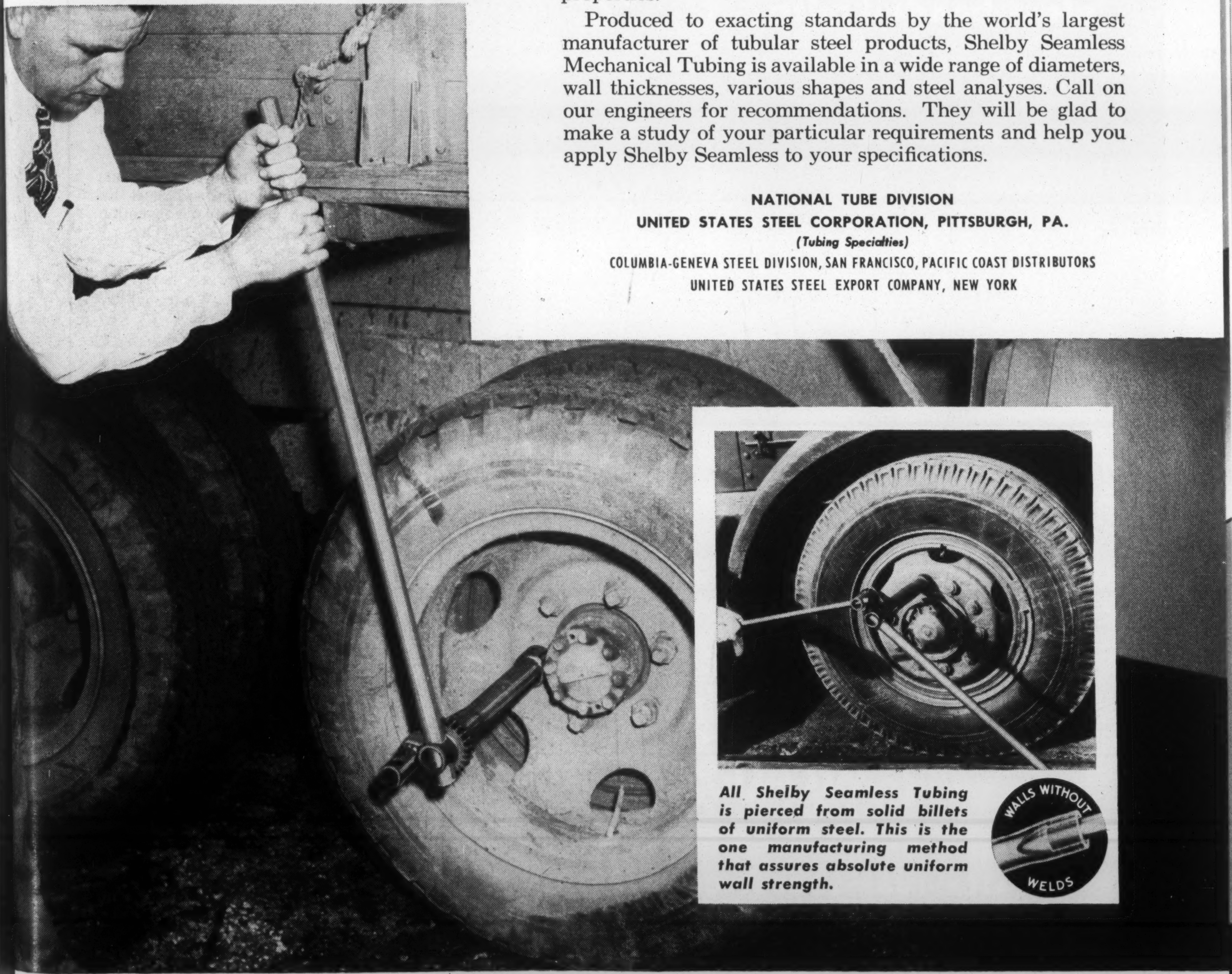
Shelby and Sweeney tame a tough nut

• The Sweeney Powerench is a rugged nut turning tool specifically designed with geared action for tightening or loosening the nuts on dual wheels, aircraft propeller shafts, diesel engine cylinder heads, railroad locomotives, and for countless other heavy-duty applications.

Super tough equipment calls for super strong materials. That's why Shelby Seamless Mechanical Tubing—in sizes from 1⅛ in. O.D. to 5⅝ in. O.D.—is used in the manufacture of Powerench assemblies. The great strength, complete uniformity, and extreme dimensional accuracy of Shelby Seamless make it the ideal mechanical tubing for the fabrication of such heavy-duty materials. Moreover, it is safe and workable—possessing excellent machining and superior welding properties.

Produced to exacting standards by the world's largest manufacturer of tubular steel products, Shelby Seamless Mechanical Tubing is available in a wide range of diameters, wall thicknesses, various shapes and steel analyses. Call on our engineers for recommendations. They will be glad to make a study of your particular requirements and help you apply Shelby Seamless to your specifications.

NATIONAL TUBE DIVISION
UNITED STATES STEEL CORPORATION, PITTSBURGH, PA.
(Tubing Specialties)
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK



All Shelby Seamless Tubing is pierced from solid billets of uniform steel. This is the one manufacturing method that assures absolute uniform wall strength.

USS SHELBY SEAMLESS MECHANICAL TUBING

USS

4-1226

UNITED STATES STEEL

At last!
Printed Circuit
Tube Sockets that

—withstand punishing shock and vibration

made of
MYCALEX® 410
glass-bonded mica

- LOSS FACTOR .014 at 1 mc/s
- POWER FACTOR .0015 at 1 mc/s
- HIGH DIELECTRIC STRENGTH
- NO CARBONIZATION
- ZERO COLD FLOW
- IMMUNE TO FUNGUS

MYCALEX printed circuit tube sockets effectively eliminate broken or loose connections that ordinarily result from tube insertion and removal, shock and vibration. An exclusive MYCALEX contact design permits a positive mechanical attachment in conjunction with a soldered connection. The mechanical attachment safeguards against stress at all times, insures the permanence of the soldered connection between printed circuit and socket contact. Troublesome intermittent contacts, costly repairs are thus eliminated.

Application of these sockets to your printed circuit can speed production, reduce rejects, improve performance. For information call or write J. H. DuBois, Vice President-Engineering, at Clifton, N. J., address below.

NOTE: MYCALEX 410 glass-bonded mica is an exclusive formulation of and manufactured only by the Mycalex Corporation of America. It meets all the requirements for Grade L-4B under Joint Army-Navy Specifications JAN-I-10.

SINCE 1919
MYCALEX®
THE INSULATOR

MYCALEX TUBE SOCKET CORPORATION
Under exclusive license of Mycalex Corporation of America,
World's largest manufacturer of glass-bonded mica products
ADDRESS INQUIRIES TO—
General Offices and Plant: 124 Clifton Blvd., Clifton, N. J.

For more information, turn to Reader Service Card, Circle No. 437

Meetings and Expositions

SOCIETY OF AUTOMOTIVE ENGINEERS, West Coast meeting. Los Angeles. Aug. 16-18, 1954.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, fall meeting. Milwaukee. Sept. 8-10, 1954.

METAL POWDER ASSOCIATION, fall meeting. Hot Springs. Sept. 10-12, 1954.

SOCIETY OF AUTOMOTIVE ENGINEERS, national tractor meeting and production forum. Milwaukee. Sept. 13-16, 1954.

INSTRUMENT SOCIETY OF AMERICA, international instrument congress and exposition. Philadelphia. Sept. 13-20, 1954.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, INSTRUMENTS AND REGULATORS DIV. AND INSTRUMENT SOCIETY OF AMERICA, exhibit and joint conference. Philadelphia. Sept. 13-24, 1954.

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, annual meeting. Philadelphia. Sept. 21-23, 1954.

STEEL FOUNDERS' SOCIETY OF AMERICA, fall meeting. White Sulphur Springs, W. Va. Sept. 27-28, 1954.

ASSOCIATION OF IRON AND STEEL ENGINEERS, Iron and Steel Exposition and annual convention. Cleveland. Sept. 28 - Oct. 1, 1954.

PORCELAIN ENAMEL INSTITUTE, annual meeting. White Sulphur Springs, W. Va. Sept. 29 - Oct. 1, 1954.

STANDARDS ENGINEERS SOCIETY, annual meeting. Atlantic City. Oct. 1-2, 1954.

ELECTROCHEMICAL SOCIETY, fall meeting. Boston. Oct. 3-7, 1954.

SOCIETY OF AUTOMOTIVE ENGINEERS, national aeronautics meeting, aircraft production forum and aircraft engineering display. Los Angeles. Oct. 5-9, 1954.

NATIONAL FOUNDRY ASSOCIATION, annual meeting. Chicago. Oct. 6-8, 1954.

AMERICAN GAS ASSOCIATION annual convention. Atlantic City. Oct. 11-14, 1954.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, fall meeting. Chicago. Oct. 11-15, 1954.

NATIONAL ASSOCIATION OF CORROSION ENGINEERS, south central regional meeting. Dallas. Oct. 12-15, 1954.

SOCIETY OF AUTOMOTIVE ENGINEERS, national transportation meeting. Boston. Oct. 18-20, 1954.

Basic Materials Conference and Exposition. Philadelphia. June 12-16, 1955.

For more information, Circle No. 468 ➤

bright
strong
easy to
form
for everything
AND the kitchen
sink
Superior Type 430
Stainless STRIP STEEL

SINK RIMS are an excellent example of Superior Stainless in service—all the way from initial ease of fabrication, through simplicity of installation, to life-long durability on the job. Rims of Superior Stainless stay bright with a wipe—can't rust, peel or chip—add value to the entire kitchen unit! ● Let's help you find *your* profit-application for Superior Stainless Strip Steel. Write us about your product, today.

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CORPORATION
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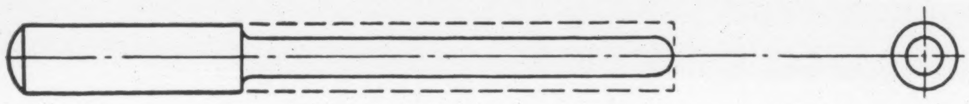
Swaging
Success
Stories

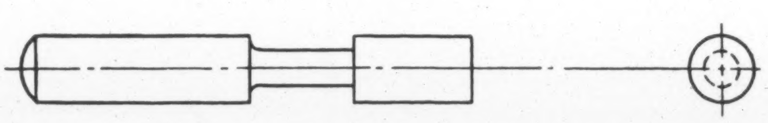
THE
TORRINGTON
SWAGING
MACHINE
The Torrington Company
Torrington, Conn. U.S.A.

Close Tolerances . . .
without Machining

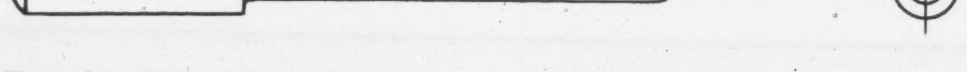
Why not write for our informative booklet on swaging that includes complete descriptions of Torrington Rotary Swagers. It may show you how you can achieve a "swaging success story" in your own plant.



This finished piece used to be made on an automatic screw machine with the long, narrow diameter section turned to .100 ±.003 and a necessary sharp shoulder.



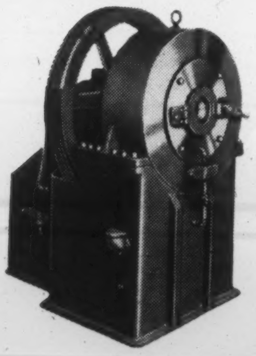
Torrington's swaging experts suggested starting with this simple screw machine blank (to retain the required shoulder).



Result after one rotary swage—an improved finished piece, to a tolerance of ±.001.

See what savings you can make by swaging

1. Saving in material—swaging uses nearly all the metal.
2. Saving in time—swaging is fast.
3. Saving in labor—unskilled labor can run a swager.
4. Saving in machining—swaging produces finishes accurate to ±.001.
5. Saving in finishing operations—swaging produces high finish, better hardness and resiliency.



THE TORRINGTON COMPANY
Swager Department
660 North Street, Torrington, Conn.
Makers of Torrington Needle Bearings

TORRINGTON *ROTARY SWAGING* MACHINES

For more information, turn to Reader Service Card, Circle No. 328

News Digest

Tinplate Substitutes . . .

continued from page 13

of the first alternates for tin plate. Large quantities were produced during the tin shortage during World War II, but the production of treated steel was discontinued when tin became more available. New interest in substitute material has resulted in a reinvestigation of methods for continuously treating coils of steel. Results have been encouraging and current attempts are aimed toward cost reduction so that the plate may better compete with other sheet metals. Chemically treated plate should be applicable to ends of cans for low acid foods and also for bodies if side closure methods can be devised. Adhesive bonding for side closure should make it possible to employ the plate in cans for a number of products which do not require processing.

Aluminum

"Aluminum has properties that are both attractive and unattractive to the can maker," Dr. Lueck stated. "The fact that gage for gage aluminum is only 36% as heavy as tin plate is advantageous. The relative softness of pure aluminum is one of its greatest disadvantages. The can manufacturers working with aluminum must take into consideration composition and temper as well as gage, in tailoring a can to given requirements."

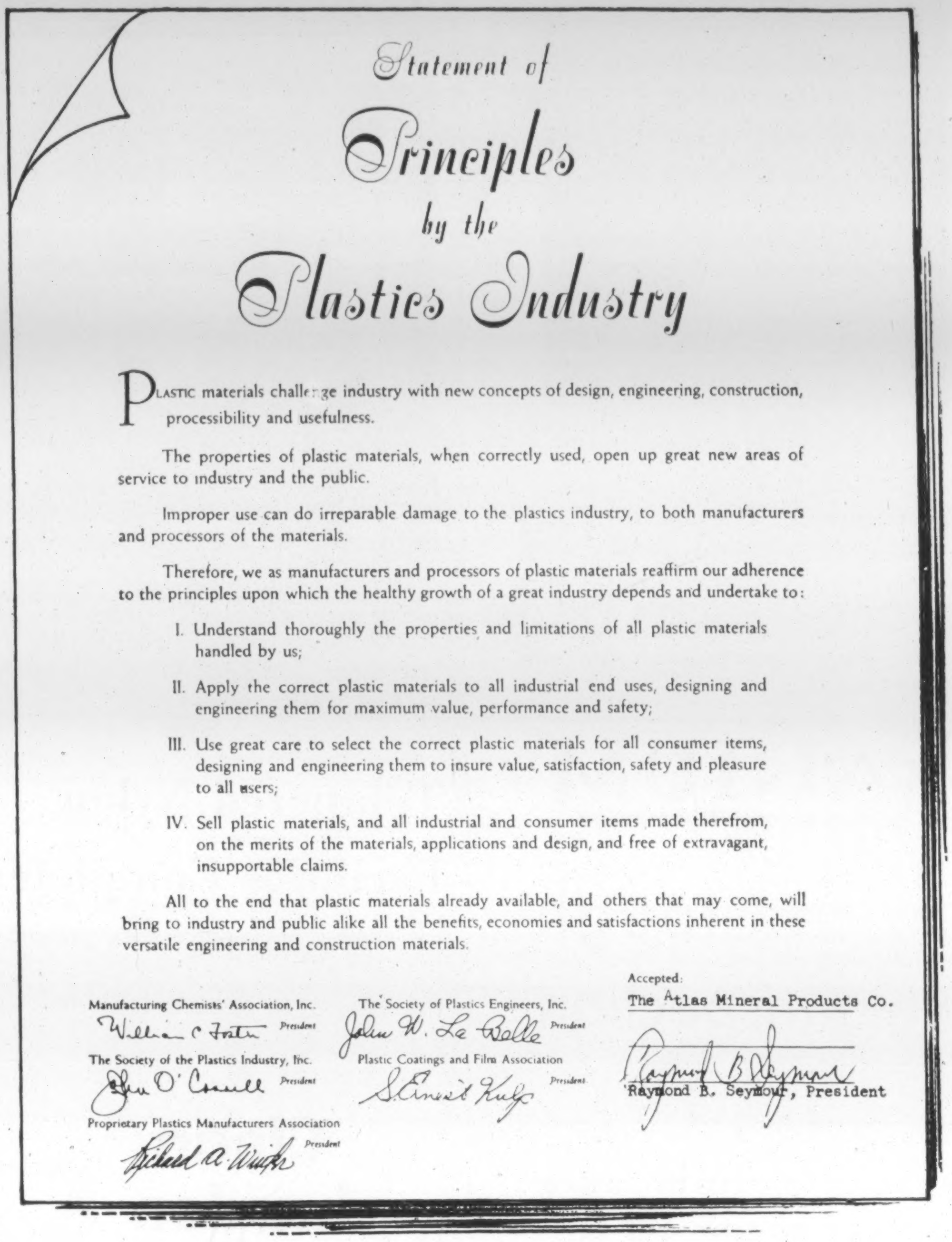
Considerable information is available on the use of aluminum containers, as they are widely used in Europe, and have been made up in experimental packs in this country.

Aluminum coated steel holds some promise as a can material, but processes are still only approaching the pilot plant stage. Target is to apply enough of the less expensive aluminum to provide about the same rust resistance as does tin when applied at a quarter pound per base box, a tin coating which performs well under domestic canning and food distribution conditions.

Zinc and Nickel

Although nickel and zinc coatings have been under consideration for a long time as alternated to tin, neither is expected to find great acceptance. Both would be limited to specific classes of products, and strategic importance of nickel would make it almost as unavailable as tin in the event of an emergency.

(More News on page 192)



Statement of
Principles
by the
Plastics Industry

Plastic materials challenge industry with new concepts of design, engineering, construction, processibility and usefulness.

The properties of plastic materials, when correctly used, open up great new areas of service to industry and the public.

Improper use can do irreparable damage to the plastics industry, to both manufacturers and processors of the materials.

Therefore, we as manufacturers and processors of plastic materials reaffirm our adherence to the principles upon which the healthy growth of a great industry depends and undertake to:

I. Understand thoroughly the properties and limitations of all plastic materials handled by us;

II. Apply the correct plastic materials to all industrial end uses, designing and engineering them for maximum value, performance and safety;

III. Use great care to select the correct plastic materials for all consumer items, designing and engineering them to insure value, satisfaction, safety and pleasure to all users;

IV. Sell plastic materials, and all industrial and consumer items made therefrom, on the merits of the materials, applications and design, and free of extravagant, insupportable claims.

All to the end that plastic materials already available, and others that may come, will bring to industry and public alike all the benefits, economies and satisfactions inherent in these versatile engineering and construction materials.

Manufacturing Chemists' Association, Inc.
William C Foster President

The Society of the Plastics Industry, Inc.
John O'Connell President

Proprietary Plastics Manufacturers Association
Richard A. President

The Society of Plastics Engineers, Inc.
John W. Le Belle President

Plastic Coatings and Film Association
S. Ernest Kulp President

Accepted:
The Atlas Mineral Products Co.
Raymond B Seymour
Raymond B. Seymour, President

We firmly believe that the practice of these principles which are completely in accord with the ATLAS POLICY will minimize misapplication of Plastic Materials of Construction. Customers should have confidence in firms complying with these principles.

Based on over sixty years adherence to this policy, ATLAS will continue to do all within its power to: Understand thoroughly, Apply correctly, Select carefully, and Sell on merit, all plastic materials for corrosion-proof construction that it produces.

PLASTIC
CEMENTS • COATINGS
RIGID FABRICATIONS • PIPE
LININGS • FOAMS

ATLAS MINERAL PRODUCTS CO.
MERTZTOWN, PENNSYLVANIA

PLASTIC MATERIALS FOR CORROSION-PROOF CONSTRUCTION

For more information, turn to Reader Service Card, Circle No. 422

Use

THIS PHOTO shows radium being used to take a radium-radiograph of a weld. Placing the radium centrally in the pipe and the film on the outside (held in place by white tape) permits radiographing the entire circumferential weld with one exposure.

RADIUM

for the tough weld inspection jobs

because radium-radiographing equipment is

1. **Portable**
2. **Easily handled**
3. **No training needed to operate**
4. **Economical**

●

For the same reasons that radium-radiography has won nearly universal acceptance in steel foundries throughout the country, it is becoming the preferred means of inspection in welding shops.

No capital investment is required to have radium-radiography available for the inspection of welds because the equipment may be rented or leased with economy.

Write today for case histories and additional information.

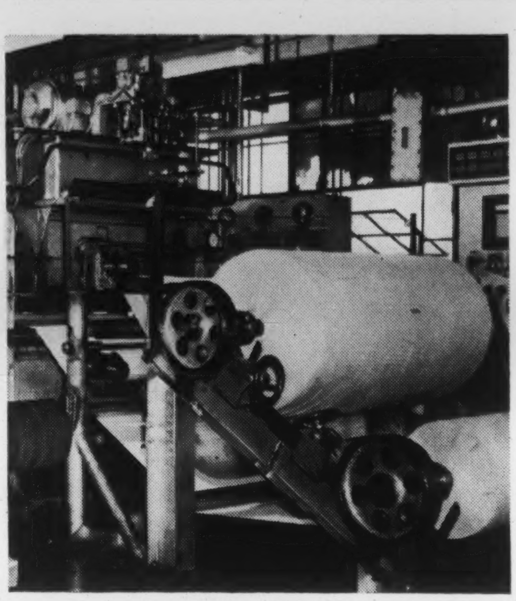
●

RADIUM CHEMICAL CO., INC.

161 East 42 Street, New York 17, N. Y.
Marshall Field Annex Bldg., Chicago, Ill.
3974 Wilshire Blvd., Los Angeles 5, Cal.

For more information, Circle No. 389

News Digest (continued)



Nylon Tire Cord Fabric is fed into stretching machine at the beginning of toughening process.

Tempered Nylon Facilities Completed

"Stretchless" nylon has proved to be such a good tire cord material that the Goodyear Tire and Rubber Corporation has built three huge new installations to temper the synthetic fiber.

Ordinary nylon tends to stretch uncontrollably at temperature and results in carcass growth and poor adhesion with rubber, but nylon treated chemically and stretched under controlled temperature and time loses its bad elongation characteristics without losing the advantages of strength, lightness, and heat and fatigue resistance.

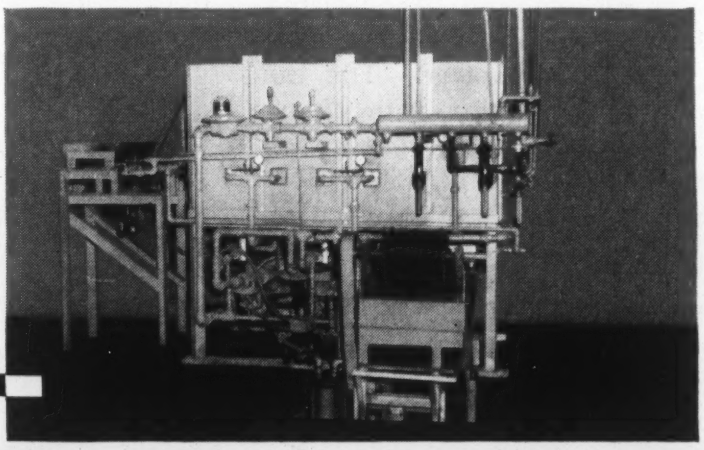
In order to translate laboratory procedures for tempering nylon into practical continuous process techniques, Goodyear has built three huge stretching machines which keep over a third of a mile of nylon cord fabric in tension at one time. The nylon "sets" during the process at its point of maximum strength and resiliency.

Tires made with the tempered nylon cord are claimed to have more heat resistance, less tire growth and tread cracking, and higher bruise resistance.

(More News on page 194)

Clean harden even *smallest* parts

S&W



SHAKER HEARTH with AUTOMATIC QUENCH

Have Samples Processed Free

Demonstration is more convincing than description! We'll show you how well the S & W Shaker Hearth can do your work — hardening, nitriding, carburizing, carbonitriding. Just send us small part samples and specifications. Without obligation, you judge the results.

You can clean harden a wide range of small parts economically — even the *smallest,* because muffle surface is smooth instead of grilled. There are no openings for small parts to clog or drop thru. Heat and atmosphere are conserved because muffle which carries work never leaves the furnace. Discharge is direct to automatic quench. Since no pit is needed for the quench, it may be used on floor level where convenient. Air operated, with high degree of variable feed from slow to fast. Accurate control settings do not vary, are easily reproduced. Option of oil, water quench, or heated salt for martempering and interrupted quench. Electrical or gas heated. Coolers, filters, pumps as required. Plan on high production at low cost.

S&W

SARGEANT & WILBUR, INC.
181 Weeden Street, Pawtucket, R. I.

Complete Line of Electric and Fuel-Fired Furnaces To Meet Every Industrial Need
Atmosphere Generators • Ammonia Dissociators • Gas Conditioning Equipment

For more information, turn to Reader Service Card, Circle No. 405

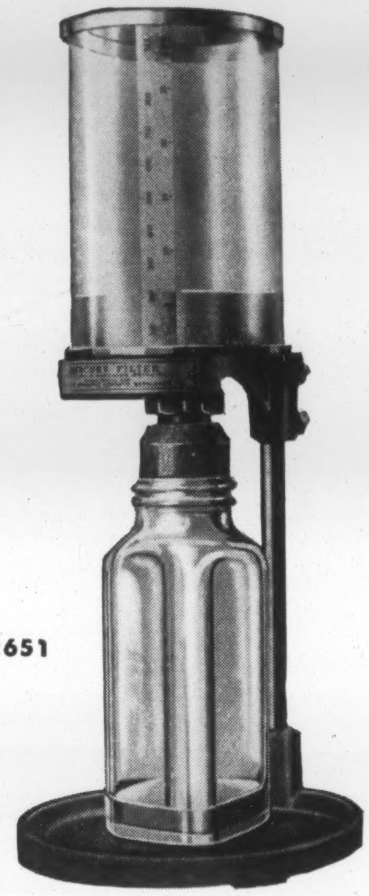
BEAT THE HIGH COST OF MERCURY!

Thorough Mercury cleaning with the MERCURY OXIFIER and GOLD ADHESION FILTER

H-22650

H-22650-10

H-22651-10



H-22651

PRINCIPLE OF THE OXIFIERS

The Oxifier acts in two ways to oxidize base metals. Paddles, developed for the work and driven by motor, (1) produce a copious spray and subject the resulting fine mercury droplets to repeated contact with air; and (2) break up oxide skins, and carry them under and through the mercury mass until oxidation is complete. After this treatment nothing oxidizable remains in the mercury.

PRINCIPLE OF THE GOLD-ADHESION FILTERS

Action of the Filter is not that of straining through small holes—the usual understanding of "filtering"—but the principle of decanting. All foreign substances—the oxidized precipitates formed by the Oxifier, water, oil, etc.—float on mercury, leaving the central body clean. The filter draws from this clean central body and decants through a large aperture in the bottom.

Mercury does not "wet" the sides of a container, and contaminants work down between mercury and sides and would flow through the bottom aperture, except for the gold seal. This is a ring of gold alloy surrounding the aperture, and since gold is wet by mercury the adhesion between the two elements forms a positive seal through which contaminants cannot pass. Exacting tests show this gold-adhesion principle to be completely effective; removal of impurities is not partial as with chamois skin, seepage through porous members, etc. Mercury emerges in a bright, lively stream, bone-dry and entirely free of acid or oil film.

GENERAL LABORATORY SET

H-22650—25-lb. Oxifier—Cleans 100 lbs. a day in 25-lb. batches. Oxidizes dissolved base metals. Height 17½"; table space 16" x 10"; weight 63 lbs.; Motor 1/12 HP, 115 V, 60 Cy. A.C.; V-belt drive; switch on motor. All exposed parts finished in green and black enamel. Complete, ready to run. Each **$180.00**

H-22651—Type "F" Filter—Eliminates floating impurities; water, oil, oxide-dust; but NOT dissolved metals. Height 17"; table space 7" x 7"; weight 5¼ lbs.; Plastic acid-resistant reservoir holds 25 lbs.; filters in six minutes. Provided with shut-off valve. Cast iron frame finished in green and black enamel; other parts stainless steel. Each **$50.00**

SMALL SET

H-22650-10—5-lb. Oxifier—Cleans 20 lbs. a day in 5-lb. batches. Oxidizes dissolved base metals. Height 7"; table space 9" x 5"; weight 8 lbs.; Motor, direct-connected 1/70 HP, 115 V, 60 Cy. A.C., with line switch. Cast iron frame, finished in green and black enamel. Each **$77.50**

H-22651-10—Type "G" Filter—Eliminates floating impurities; water, oil, oxide-dust; but NOT dissolved metals. Height 6½"; table space 3½" dia.; weight 1 lb., 2 oz.; No reservoir or shut-off valve; mercury can be poured through at rate of 5 lbs. in two minutes. Plastic and stainless steel. Each **$20.00**

HARSHAW SCIENTIFIC
DIVISION OF THE HARSHAW CHEMICAL CO.
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Cleveland 6, Ohio
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Cincinnati 13, Ohio
6265 Wiehe Road
Detroit 28, Mich.
9240 Hubbell Ave.

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6622 Supply Row
Los Angeles 22, Calif.
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Philadelphia 48, Pa.
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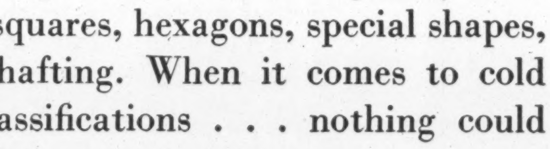
half
your job is done for you–
when you choose
WYCKOFF
COLD FINISHED STEELS
CARBON . . . ALLOY . . . LEADED

√ ***Precision Dimensions***
√ ***Precision Cross Section***
√ ***Pre-finished Surface***

In this age of specialization nothing serves like the highly trained craftsmanship and concentrated experience of the specialist. WYCKOFF has specialized in fine quality cold finished steels . . . rounds, squares, hexagons, special shapes, wide flats and precision shafting. When it comes to cold finished steels in these classifications . . . nothing could be finer.

WYCKOFF STEEL PRODUCTS
Carbon and Alloy Steels
Turned and Polished Shafting
Turned and Ground Shafting
Wide Flats up to 12" x 2"
All types of furnace treated Steels

COLD FINISHED STEEL
Controlled CARBON and ALLOY

SPECIALISTS IN COLD FINISHED STEELS EXCLUSIVELY
WYCKOFF
STEEL COMPANY

GENERAL OFFICES: Gateway Center
Pittsburgh 30, Pa.
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Works: Ambridge, Pa. • Chicago, Ill. • Newark, N. J. • Putnam, Conn.

For more information, turn to Reader Service Card, Circle No. 356

News Digest

Metal press stamps top and bottom of box from Geon plastic each 10-sec cycle.

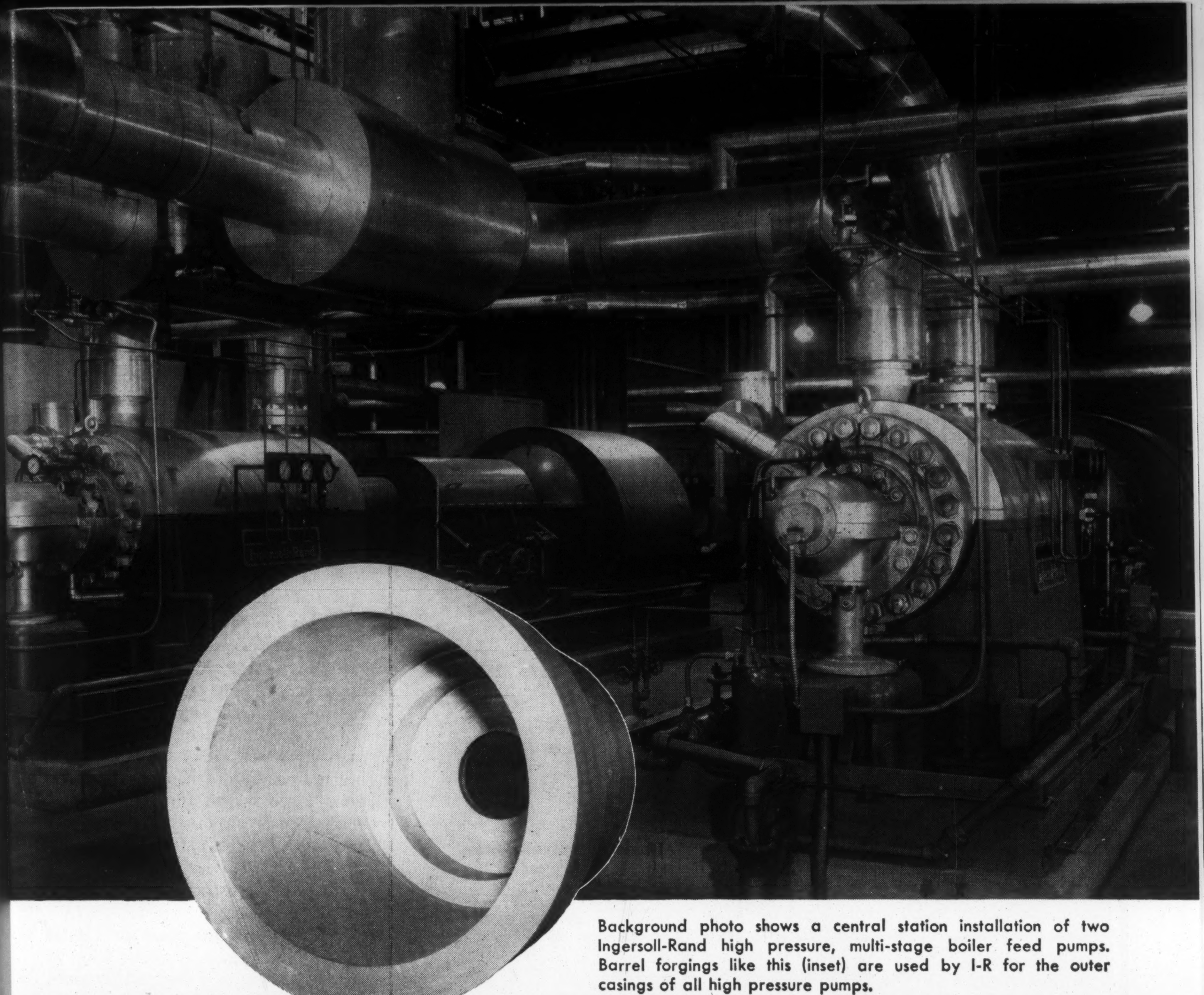
Metal Press Stamps Plastics

With a few simple changes, metal stampers can get into the plastics business, according to the B. F. Goodrich Chemical Company. In a display at the National Plastics Exposition, the plastics supplier demonstrated how a standard metal stamping press could be converted to stamp out finished boxes of rigid vinyl plastic, with very little capital outlay required.

The outfit demonstrated consisted of a standard metal stamping press with matched metal dies. Vinyl sheet 1/20 in. thick was fed from rolls through a bank of strip heaters, which raised its temperature to 260-275 F. Two sets of rubber rollers controlled the movement of the sheet through a clutch arrangement which fed the sheet intermittently to the press bed. Cycle time was 10 sec and the excess sheet was cut off during the molding operation. Finished boxes conformed to the tolerance of the molds.

Oxygen Steel Process Licensed to U.S. Firm

Kaiser Engineers Division of Henry J. Kaiser Company has acquired the exclusive rights in the United States for the European oxygen steel-making process. A number of European firms are now using this



Background photo shows a central station installation of two Ingersoll-Rand high pressure, multi-stage boiler feed pumps. Barrel forgings like this (inset) are used by I-R for the outer casings of all high pressure pumps.

Ingersoll-Rand tells how:
STEEL FORGINGS HELP GIVE LONG LIFE TO HIGH PRESSURE BOILER FEED PUMPS

Ingersoll-Rand Class CHTA boiler feed pumps are widely used in high pressure central power generating stations throughout the world. They are double-case units, the inner assembly containing the rotor and fluid passages and the outer casing providing the pressure vessel to enclose this pumping unit.

For service under high pressures and temperatures, Ingersoll-Rand uses steel forgings for the outer casing of these boiler feed pumps. Since Standard Steel forges these outer barrels from solid billets of high carbon steel, they have a close grained, homogeneous structure. That's a big reason why Ingersoll-Rand double-case pumps have established a reputation for long, trouble-free service with sustained high efficiency.

Very likely, you can improve *your* products by using Standard Steel barrel forgings, rolled rings, flanges or other forgings. Our engineering and metallurgical departments have helped solve many diverse problems. Please write us about yours.

BALDWIN BLH LIMA-HAMILTON

Standard Steel Works Division

Burnham (Mifflin County), Pa.

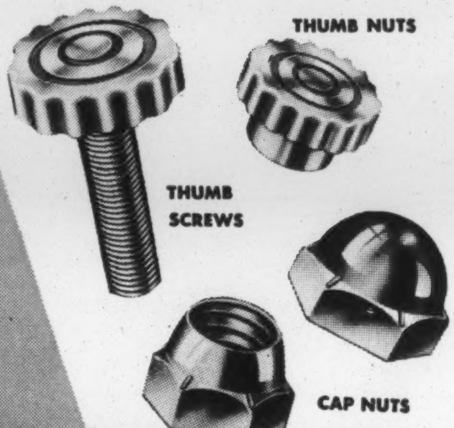
BALDWIN-LIMA-HAMILTON

General Offices: Philadelphia 42, Pa. Offices in Principal Cities

For more information, turn to Reader Service Card, Circle No. 461

here's what **DIE CAST GRC** ZINC ALLOY THREADED **FASTENINGS** mean to you...

WING NUTS
WING SCREWS



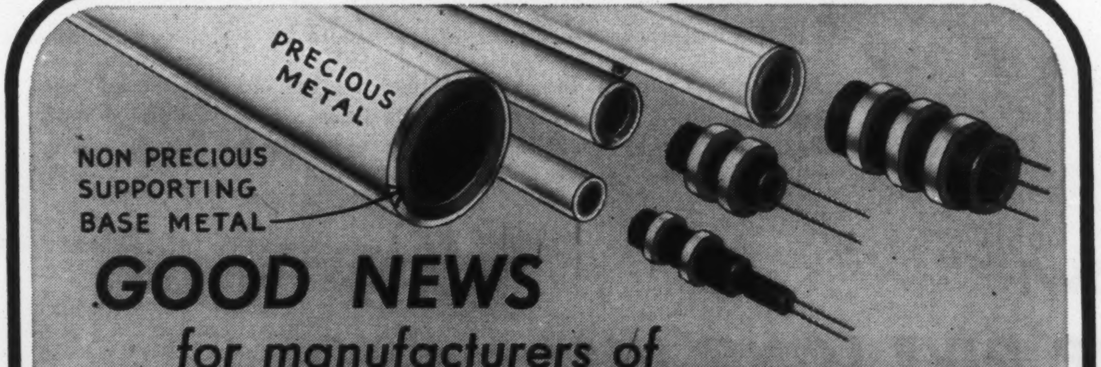
in terms of a better product, in terms of a more economical product! *Every Quality Feature is an Economy Feature!* ● The plain bright finish does not require further surface finishing for most applications ● Closer tolerances ● Cleaner threads ● Greater dependability, durability ● Die-cast uniformity. LOWER PRICED!

NON-FERROUS ● RUST-PROOF ● CORROSION-RESISTANT

Quick deliveries from stock • Specials to order
WRITE TODAY FOR SAMPLES, PRICES & BULLETINS

GRIES REPRODUCER CORP.

World's Foremost Producer of Small Die Castings
153 Beechwood Av., New Rochelle, N. Y. NEw Rochelle 3-8600



GOOD NEWS
for manufacturers of
MINIATURE SLIP RING ASSEMBLIES

Increasing demand for Improved's tubing for slip rings has led to expanded production! Improved can now supply (with a maximum of 3 weeks' delivery) tubing for slip ring assemblies in any of the noble metals, such as gold and silver, in alloyed form or laminated to a non-precious, non-costly base metal that supplies all the strength and rigidity needed.

MAXIMUM DIAMETER 1" x .060

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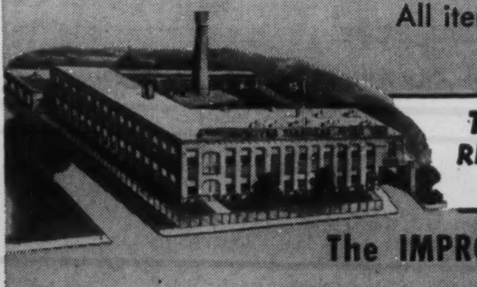

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News Digest

new approach to steelmaking. Combining the high tonnage, low cost features of the Bessemer process with the high quality of the open hearth furnace, this new oxygen converter process promises to be one of the most important steelmaking advances in the last 50 years.

With three plants now operating in Europe on a commercial basis and one plant under construction in Canada, the oxygen process is demonstratively beyond the pilot plant stage and is an accepted addition to the art of making steel.

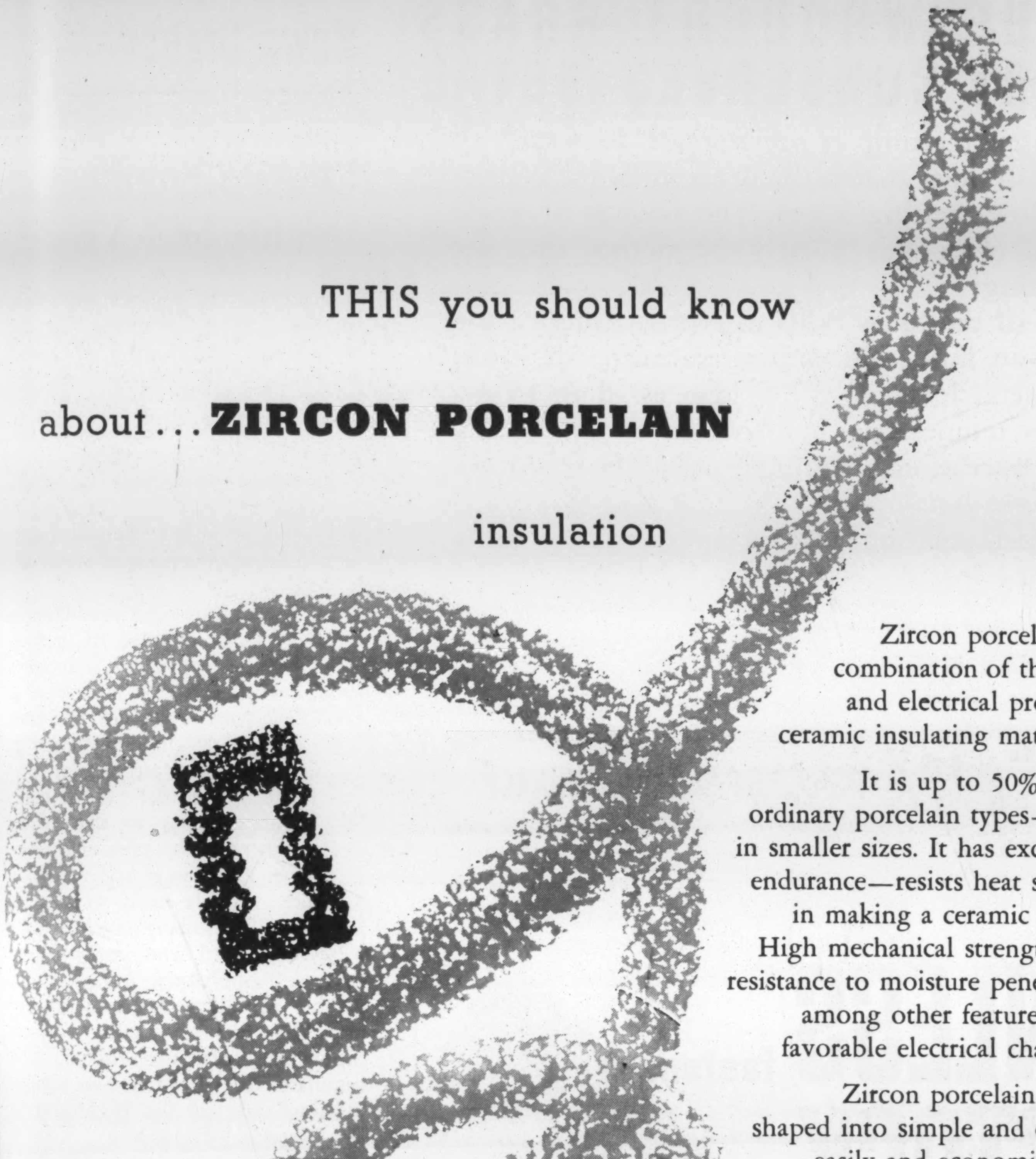
The process is relatively simple in principle, consisting essentially of blowing a jet of high purity oxygen upon the surface of a molten pig iron bath in a converter vessel. A wide range of pig iron analyses can be refined by this process and the quality of the resulting steel is as high and can be as closely controlled as in open hearth practice. Up to 25 per cent of the charge can be scrap metal.

Estimated production tonnages for each converter are 2-½ to 3 times higher per hour than the conventional open hearth furnace. The operating costs (exclusive of metallics and fixed charges) for each ton of steel produced is at least $3 lower than similar costs for open hearth steel.

Current estimates place the capital cost of an oxygen converter shop at 50% or less than a comparably sized open hearth shop, depending on size, location, available facilities, and other variable factors.

Brassert Oxygen Technik A. G. is a Swiss company organized for the development and dissemination of operating techniques and designs for world-wide use. Continental European firms who have and will contribute operating and design data are: Vereinigte Oesterreichische Eisen- und Stahlwerke A. G., Linz, Austria; Westerreichische-Alpine Montangesellschaft A. G., Donawitz, Austria; Mannesmann Huettenwerke A. G., Huckingen, Duisburg, Germany; John Miles & Partners, Ltd., London, England; and H. A. Brassert & Company, Berlin-Charlottenburg, Germany. Dominion Foundry and Steel Company of Hamilton, Ontario, Canada as sole Canadian licensor of Brassert Oxygen Technik A. G. is currently building a commercial plant which will be in operation later in 1954.

(More News on page 198)



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HOW THE WROUGHT BRASS INDUSTRY CONSERVES METAL

No industry melting *commensurate tonnage** of vital metal can quite match the brass mills for conservation and low melting losses. The savings of metal total millions of pounds; clearly the method they use is worth noting:

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News Digest

Plastics Volume to Double in 4 Years

Production of plastics will double in four years, reaching 6-billion pounds by 1958, John J. O'Connell, president of The Society of the Plastics Industry, Inc., predicted at the closing of the Sixth National Plastics Exposition and Conference.

Estimated production of plastics materials will exceed 3-billion pounds this year, he added. This is equivalent to a dollar volume of about $1.5 billion.

O'Connell based his prediction on the favorable response of industry to new plastic materials, fabrication techniques, machinery, and applications developed in the last few years.

In explaining his prediction of doubled plastics output in four years, O'Connell likened the plastics industry's position today to that of the steel industry at the turn of the century, when alloys were first introduced to make available steels with special properties. Thus many new techniques were developed and new markets opened. Copolymers, roughly comparable to alloys, are now moving into the plastics picture. Styrene copolymers, utilizing rubber, have stimulated the rapid rise in vacuum forming, one of the highlights of this week's Exposition. Vacuum forming, it was evident at the show, is moving into a number of fields of plastics application formerly held by conventional molding techniques. In vacuum forming, a softened plastic sheet is formed into complex shapes in a matter of seconds by suction over a low-cost die.

Polyesters used primarily in the making of fibrous glass-reinforced products like automobile bodies, translucent panels, fishing rods, etc. are also moving into new fields. Many new applications in the form of housings, metalworking tools and dies, and unglamorous but vital industrial products attracted strong interest.

Plastics piping, it was evident, is rapidly growing in acceptance. One of the biggest outlets is in rural irrigation. Its resistance to corrosive materials has also won it a firm place in the chemical industry. Consumers will soon have an opportunity to use such pipe in the home.

Machinery developments seen at

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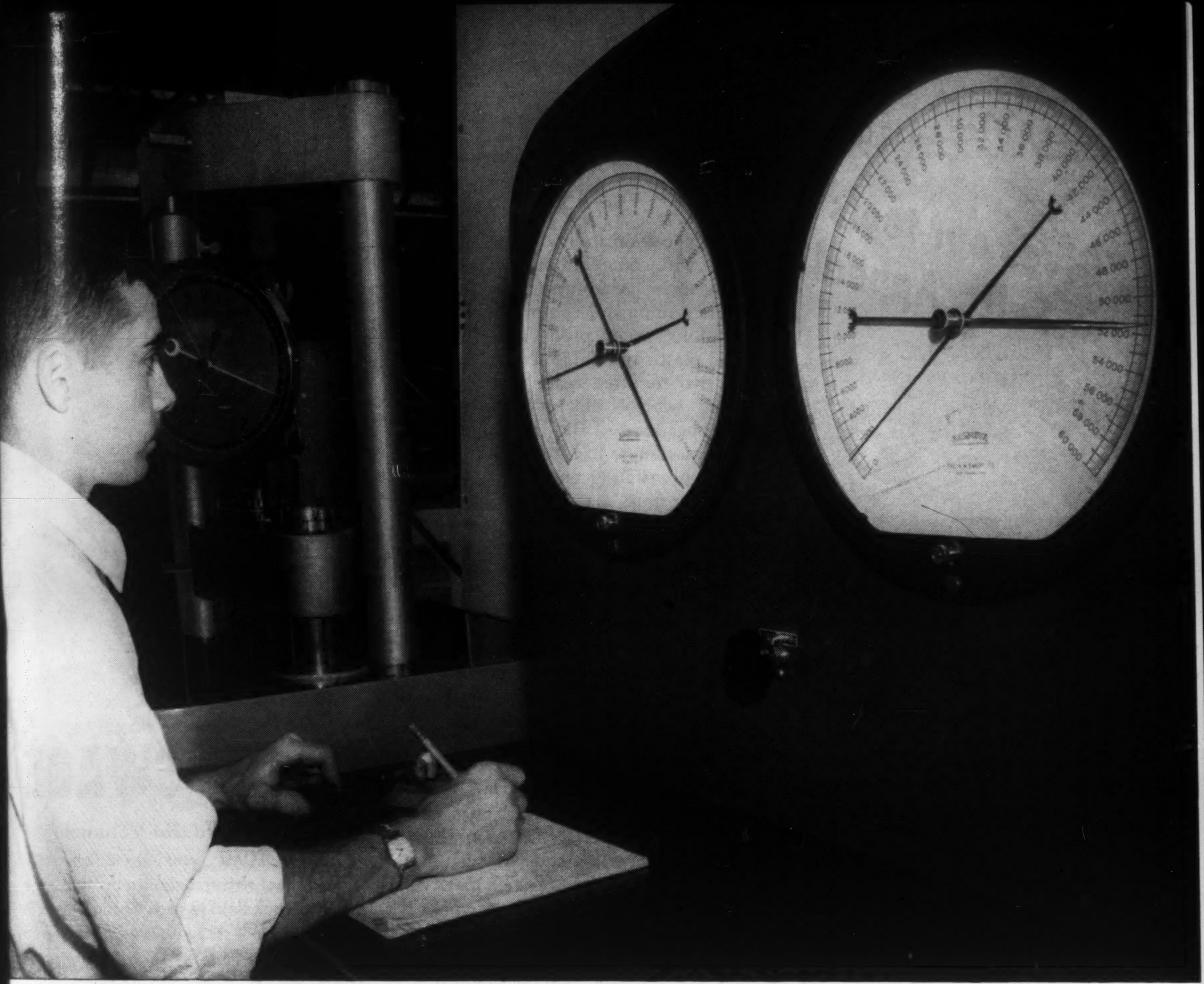

Baldwin's low-cost 60-H makes testing easy for the University of Pittsburgh

For testing parts of naval aircraft the University of Pittsburgh's Engineering Research Division uses the Baldwin 60-H. Also secondary load measuring devices such as dial type dynamometers and tension bars with SR-4 strain gages are calibrated by this testing machine.

Pitt chose the Model 60-H for testing economy and simplicity. And they've found this low-priced, easy to operate machine enables engineering students to do most of the test work. Its convenient control system, many automatic safety features and simple maintenance make testing at Pitt an easy and trouble-free operation.

The Baldwin Model 60-H gives the University of Pittsburgh *all* these testing benefits.

1. Simple operation makes it easy for engineering students to do test work.
2. The machine meets *all* requirements at low cost.
3. Accuracy of load measurements is well within laboratory requirements.
4. Separate frames for loading structure and indicator prevent transmission of shock when test specimens break.
5. Scale ranges of 0-12,000 lbs. and 0-60,000 lbs. are exactly suited to stress ranges of the test work.

Like the University of Pittsburgh, you can have *all* these benefits with the Baldwin Model 60-H. You'll learn that Baldwin designs testing machines to give outstanding performance. For more information about the Baldwin Model 60-H and other testing equipment, write now to Dept. 2523, Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa.

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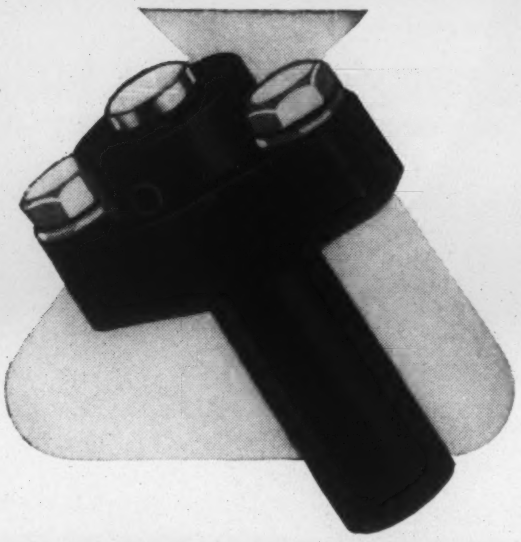

BARNABY MFG. CO. of Bridgeport, Conn., reports: "Our close proximity to salt water has given us problems in rust prevention for many years. We have experimented with many black oxide finishes but none has proven as successful, safe, and inexpensive as DU-LITE—our tools have better sales appeal—our volume has been on the increase ever since we started using this modern, progressive oxide finish."

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the Exposition indicated that automation will come into its own in the plastics industry during the next five years. Automatic controls now make possible speedy production of precision plastic moldings at rates unheard of two to three years ago. Another trend evident today is the gradual disappearance of the "medium-capacity" machines. Instead manufacturers are concentrating on small 2- to 4-oz capacity units designed to operate at high speeds, and on very large machines capable of molding at good rates parts such as large television cabinets.

One such machine, now in service, can produce two 20-in. TV cabinets every four minutes. Such cabinets use up to 35 lb of plastic each. In an eight-hour day, the machine can consume up to 6000 lb of plastics material. It is pushbutton operated.

With new manufacturing techniques, molders predicted that colored TV cabinets would soon reach the consumer market. Molded of urea—the colorful plastic material first developed at Battelle Memorial Institute for housings for meat scales—such cabinets will open new markets for TV sets. Several brand-new colored TV housings were shown at the Exposition.

One of the biggest fields for expansion of plastics is in the building field. Plastics will be soon used for structural parts of houses, for gutters, downspouts, pipe, interior walls, and eventually for exterior walls, it was predicted. A number of exhibitors had pilot models of such applications on display.

O'Connell is president of the Consolidated Molded Products Corp., Scranton, Pa. He is a vice-president of Republic Pictures Corp. and became associated with Consolidated when Republic purchased it in 1930.

Clad Metal Firm Enters Plastics Field

A leading firm in the clad metal field has decided, along with a number of steel producers, that it is time to get into the plastics business. Knapp Mills Inc. of New York, one of the largest producers of lead clad steel and lead clad copper, recently announced plans to produce large

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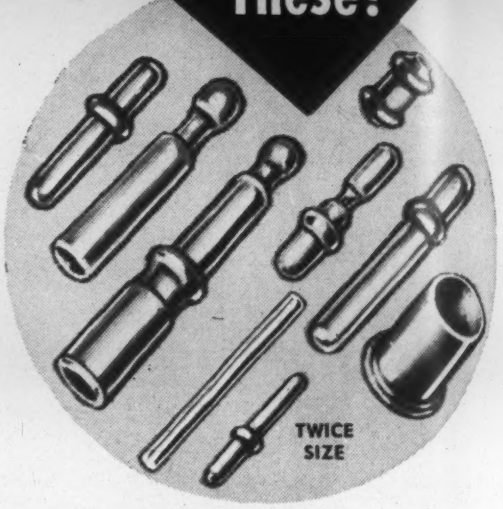

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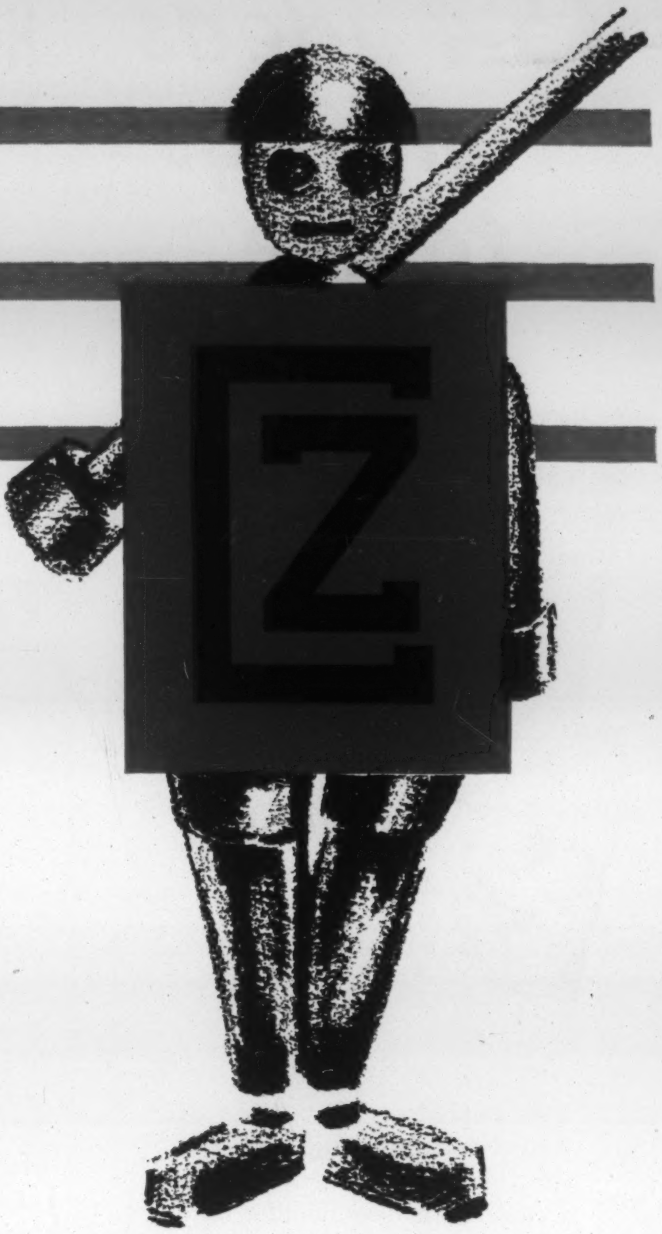

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The Superior Die Casting Company, Cleveland, Ohio
The Tool-Die Engineering Co., Cleveland, Ohio
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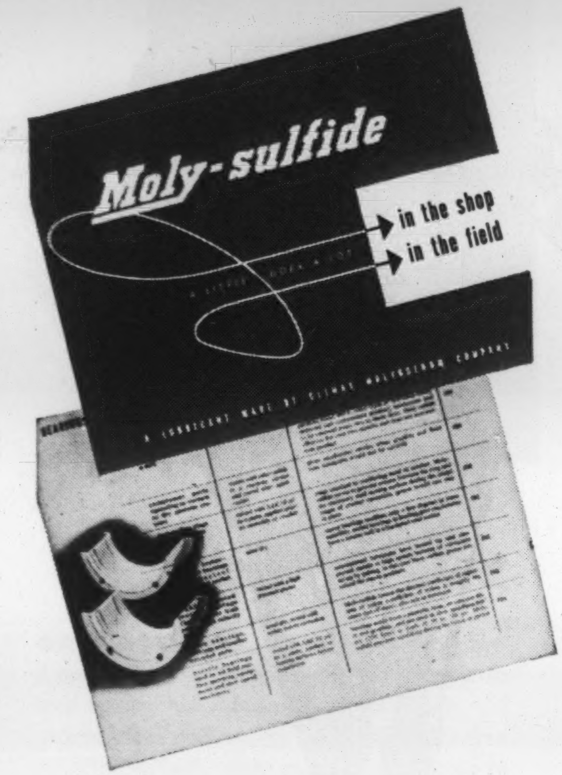

154 varied applications of molybdenum sulfide in the shop and in the field are described in a new booklet now available. This solid-film lubricant has demonstrated unique anti-friction properties under conditions of extreme pressure, high velocity, elevated temperature, or chemical attack.

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News Digest

scale chemical and process equipment from unplasticized polyvinyl chloride.

In announcing the decision to diversify into plastics fabrication, A. P. Knapp, president of the company disclosed that for the last year he had been engaged in foreign licensing programs which included a survey of latest developments in the chemical equipment field in Germany, France and Italy. "Our survey indicated that European engineers had had great success in the production of massive and complicated chemical service from plastics, some of it in service as long as fifteen years," Mr. Knapp said. He revealed that in permanently successful applications, the material which was most often used was unplasticized polyvinyl chloride.

Mr. Knapp added, "In attempting to translate and extend this European experience to the United States, we must avoid what so often happens where new and promising materials are utilized on a wide scale for complex purposes. In such cases, there is often considerable unjustified dissatisfaction resulting from misapplication, poor design, or from an improper technical understanding of the purpose for which the materials are suited. When this happens it leads to confusion, waste, and loss of production, much of which should be avoidable. The tendency, then, is to blame the basic material. Of course, after years of experience have been accumulated, everyone learns what a material can or cannot do, but it should not be necessary to needlessly expend millions of dollars by shot-gun methods of selection or employment in this day and age.

"Our investigation revealed that the use of unplasticized polyvinyl chloride in American industries has had excellent results in many of the simpler applications of this versatile plastic.

"There is no reason why the European success with plastics in the production of big equipment cannot be equalled here if these elements are present:

(a) the right material is selected for the particular job;

(b) wherever corrosion resistance is at an optimum, that the use of even minute quantities of plasticizer be avoided;

(c) the equipment is well engineered, designed, and its purpose understood."

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